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Sir William Molesworth.

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Sir William Molesworth.



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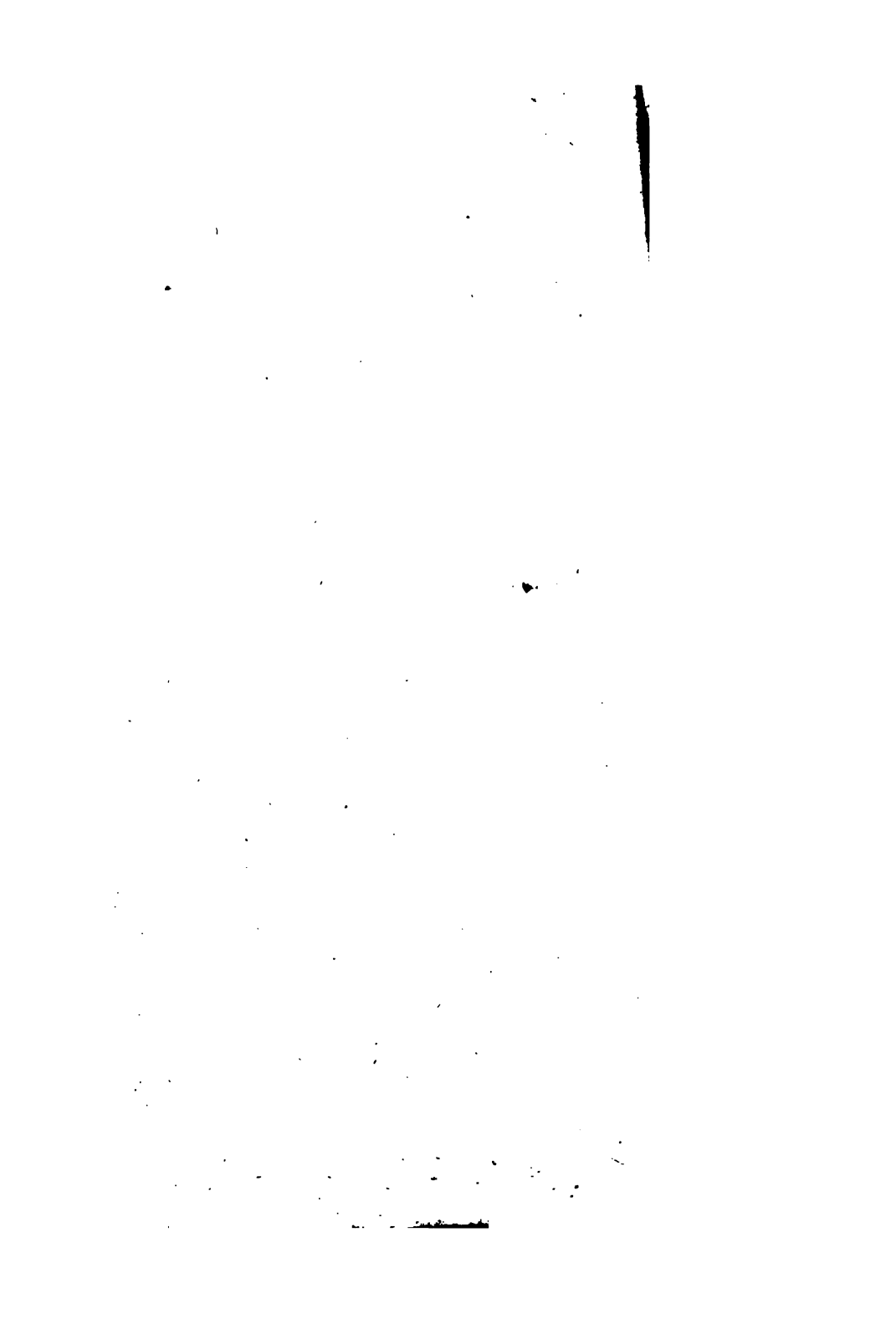
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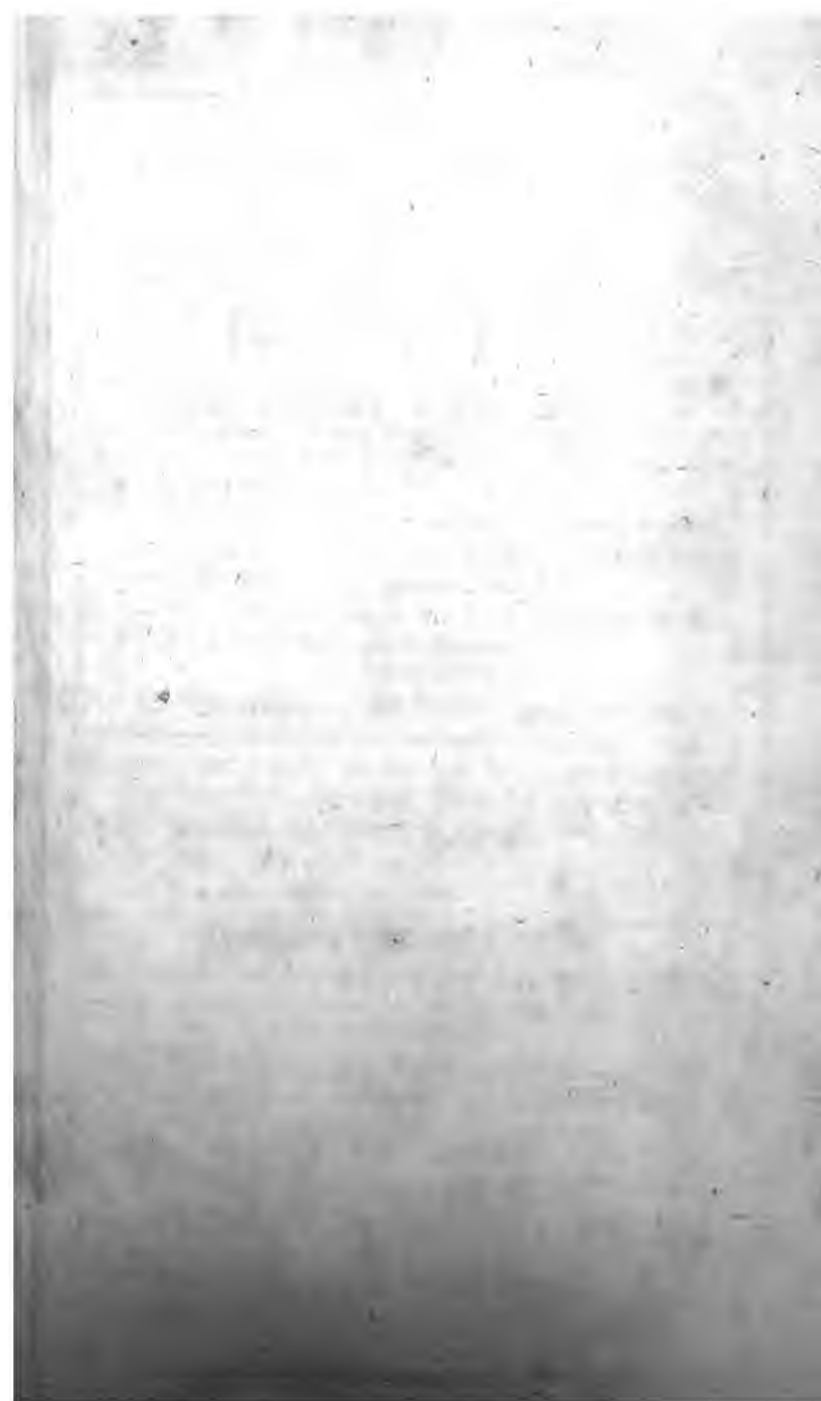
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THE 199
Religious Philosopher :
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Contemplating the Works of the
CREATOR.

In THREE VOLUMES.

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VOL. II. In the no less wonderful and wise Formation of the **ELEMENTS**, and their various Effects upon Animal and Vegetable Bodies.

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DESIGNED

For the Conviction of **ATHEISTS** *and* **INFIDELS.**

Throughout which, all the late **DISCOVERIES** in *Anatomy, Philosophy, and Astronomy*, together with the various Experiments made use of to illustrate the same, are most copiously handled by that Learned *Mathematician*, Dr. **NIEUWENTYT.**

Translated from the Original,

By **JOHN CHAMBERLAYNE, Esq; F. R. S.**

To which is Prefix'd,

A **LETTER** to the **TRANSLATOR**, by the Reverend **J. T Desaguliers, LL. D. F. R. S.**

Adorn'd with **CUTS.** The Second Edition.

L O N D O N :

Printed for **J. SENEX** in *Salisbury-Court*, and **W. TAYLOR** at the *Ship* in *Pater. noster Row.* 1721

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*Pat.
Presented
5.26.47
6.29.66*

TO THE

Most HONOURABLE

BL
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1721
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The Lord *PARKER*,
Lord High-Chancellor of Great
Britain, † &c.

My LORD,



YOU gave an Intruder
so kind a Reception at
his first Address, that
he is delighted with
a Pretence to make
you a second.

My first Attempt was to present
Your Lordship with imperfect Co-
py manner, of the Ori-
ginals

a 2

one of the *Lords Justices.*

ij *The Dedication.*

ginals of several Famous *French Philosophers*, drawn by one of the best Hands, that of the most Ingenious *Fontenelle*; than whom Sir *Godfrey Kneller*, our *British Apelles*, can hardly give an Object a more agreeable Likeness.

Now, my Lord, I am going to entertain You with a Picture of another kind, drawn by an honest plain *Dutch Philosopher*; viz. a *Sketch of Divine Wisdom and Providence*, display'd in the *Works of the Creation*; whose masterly Strokes affect the Mind with a due Admiration for the Original, which he has so well copied.

THIS Treatise of Philosophy the Author calls *The Right Use of the Contemplation of the World*, &c. Thro' the Whole of which there runs such a Strain of unaffected Piety, that I doubt not but his good Intentions,

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tentions (even tho' he had not executed them so well as he has done) must have already procured him the inward Satisfaction of that Glorious Promise made to the Father of the Faithful, and, thro' him, to all Believers; *I will be thy Shield and exceeding great Reward.*

My LORD, I beg leave to call the Learned Physician, who is my Author, the *Dutch* RAY OF DERHAM, because, like those two *English* Philosophers, he has so well prov'd the *Wisdom, Power, and Goodness* of GOD by the strongest Arguments, *Observations on Facts*, and *Demonstrations* drawn from *Experiments*. It were to be wish'd, that he had apply'd the Texts of Scripture, which he quotes, as properly as he has done his Philosophical Considerations: but since he has not so well succeeded in what may be call'd *his Divinity*, I have left several of the Texts out

of this Translation; but have re-
trench'd none of his Glosses upon
the particular Texts by him quoted,
nor any of his Glorious Tautolo-
gies, in which he does so often call
upon *Atheists* and *Infidels*; except-
ing where his Comment is wrong,
or the Repetitions are too tedious,
and, I hope, unnecessary, even for
convincing of those unhappy Men
to whom he addresses himself; of
whom it may be pronounced, that
if they still persist in the Denial of a
G O D, after so many irrefragable
Arguments, drawn from the won-
derful Structure of Humane Bodies,
and all the other Glorious Works in
the Universe, G O D will then *harden*
their Hearts, and, like the Pharisees,
they will not *be perswaded, tho' one*
rose from the Dead.

However, my L O R D, that I may
not be thought to have acted rashly
in leaving out any thing of my Au-
thor's,

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thor's, I have in this followed the Advice of several of my learned Friends, *both Philosophers and Divines*, (to whom I communicated some of these *Sheets* in MS.) and if I only said that your Lordship approv'd of this design'd Omission, the World wou'd be assur'd that I had consulted a Philosopher and a Divine: for as the *Royal Society* well know how Eminent your Lordship is in the first of these Qualifications; so many of the *Clergy* know, that a very able Prelate (now with GOD) and one mighty in Scripture-Learning, has openly profess'd, that *the Lord PARKER* is one of the greatest Divines in England.

AND here, my LORD, it may not be amiss to suggest to You, how great a Trouble I have met with, in teaching my Author to speak *English*; who by his affecting to express all his Technical Words or Terms

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of Art in his pure vernacular Tongue, such as, for instance, the *Veins, Arteries, Muscles, Fibres, Nerves,* and a thousand other *Anatomical, Physical,* and even *Mathematical* Words too, has made me take Pains unknown to my indolent Temper thro' the whole Course of my Life till now; for I have not been able to procure any Help in this Case, neither from the Living nor the Dead. Indeed the Tables and Figures of my Author (which are very curious, and taken from the most valuable Anatomists and Philosophers) have been of good use to me, where there are proper References; but those were the only Assistances I could procure here in *England*; so that for the rest, I should have been forced to guess at their Meaning, if my Learned Friend Mr. Sgravesande (*Professor of Mathematics and Experimental Philosophy at Leyden*) had not kindly interpreted to me those I could not unriddle:

unriddle: for there is no more Analogy between my Author's Terms and the *Latin* or *Greek* commonly used by all other Philosophers, than there is between them and *Hebrew* or *Arabic*. My LORD, I don't say this to praise myself or blame my Author, (who is rather to be commended for keeping up the Dignity of our Sister-Tongue, Daughter of the *Teutonic*, and Granddaughter of the *Gothic*, the common Spring of all the Western Languages of *Europe*, from North almost to South; and indeed we ourselves are not to be justify'd in losing and obsoleting so many of our most significant *Anglo-Saxon* Words and Phrases, as has been well observ'd before me by the Learned Mr. Baron *Fortescue*,*) † but to lessen my own

* In his Ingenious Remarks upon the Lord Chancellor *Fortescue*'s Book, intituled, *The Difference between an Absolute and Limited Monarchy*. Lond. Printed for E. Parker, 1714. since reprinted, with Additions.

† Now one of the Justices of the *King's Bench*.

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own Fault, and more easily to obtain your Lordship's Pardon, if the Difficulty of explaining those Terms has made me commit any Blunders.

I can't conclude, my LORD, without endeavouring to prevent your Lordship in Favour of my Author; on account of one good Quality; which for being so rare and uncommon to most Writers, makes it appear the more lovely and charming in my Eyes: it is, that altho' he passionately endeavours throughout his whole Work (and repeats it so often, almost in every Section) to magnify the Wisdom and Goodness of GOD, and to point out his Great Ends and Purposes in all the Works of the Creation; yet he is such an Enemy to Pious Frauds, and to the sup-
porting any of the Divine Attributes above-mention'd, by wrong,
or

or even doubtful and precarious Arguments, that he uses none in confuting the *Atheist* and *Sceptic*, but such as will bear even Mathematical Demonstration: This has made him a little too strict, it may be, in placing under the Class of *Things unknown*, the Motion of the *Earth*, and the rest of the *Planets* about the *Sun*, as that great Philosopher Dr. *Clarke* was pleas'd to observe, when I communicated to him the Contents of this Work; *That he could not but wonder extreamly, that in the 29th Contemplation, the Motion of the Earth should be placed among Uncertainties, after that the Parallax of the Annual Motion is so notoriously apparent in the Phænomena of Comets, &c.*

BUT I forget, my LORD, that I am wasting those precious Minutes which your Lordship employs so use-

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usefully in the Service of your King
and Country : That you may long
employ them so, is the sincere and
heartly Wish of,

My LORD,

Westm. May 13^d 1718.

Your Lordship's

Most obliged, faithful

and most humble Servant,

J. CHAMBERLAYNE.





A
L E T T E R
F R O M

The Reverend Mr. Desaguliers to
John Chamberlayne, Esq; re-
lating to the following Treatise.*

S I R,



HAVE read your Translation of
Dr. *Nieuwentyt's* excellent Trea-
tise; and highly approve your De-
sign of Publishing it, as it will be
of great Service to *Religion* and *Philosophy*.

THE Doctor's Reason *that he gives* for
writing his Book in *Dutch* (namely, that a
great many Atheistical Books having been
written in that Language, he chose to confute
the Opposers of a Providence in the same)
will be as powerful a Motive for the *translat-
ing it into* English; since we have not been
behind-hand with our Neighbours in publish-
ing

* Now Doctor of Laws.

A Letter from Mr. Desaguliers

ing the impious Conceptions and blasphemous Raillery of our Scoffers at Religion. If such of them as had been able, had *publish'd* their crude Notions in any of the learned Languages, their Books wou'd have needed no Answer, their Readers wou'd have despised them : But their Profelytes are gain'd among the Weak and Ignorant, or such conceited Debauchees as are glad to be supply'd with Means of defending their Immoralities, by attacking Religion with a shew of Wit and Argument.

WHEN an *Atheist* has the Impudence to call himself a PHILOSOPHER, some well-meaning Persons that have not much look'd into Nature, are apt to be prejudic'd against the Study of it ; as if the *Philosophy and vain Deceit*, against which the Apostle has warn'd us, had been the Contemplation of *the Works of the Creation* : Whereas it was only the Sophistry of the Schools, contriv'd to disguise Error, and defend the System of the superstitious Heathen Divinity.

HE that reads *Nieuwentyt* will easily see that a *Philosopher* cannot be an *Atheist* ; and if it were true, that a Smattering in *Physics* will give a proud Man a Tincture of *Atheism*, a deep Search into Nature will certainly bring him back to a Religious Sense of God's Wisdom and Providence.

to John Chamberlayne, Esq;

THO' we have lately had several very good Books upon this Subject, this will not be less acceptable, because it contains several fine Observations and Experiments, which are altogether new, as is also his Manner of treating the most common *Phænomena*; from which he deduces admirable Consequences in favour of a Religious Life. And I think I may say this for the *Translation*, that it will perhaps do more Good than the Original; because in giving us all his Arguments for Natural Religion, you have omitted those which his too eager Zeal made him also draw from the *Modern Philosophy for Reveald Religion*; the Weakness of which latter might give those *Free-Thinkers* occasion to triumph, who would be struck dumb at Convictions from the former. If I can be of any Service in helping you to look over the Sheets, you may readily command, Sir,

Your most Humble

And Obedient Servant,

Channel-Row,
Westminster,
Feb. 2. 1717.

J. T. D.





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THE
AUTHOR'S EPISTLE
TO THE
READER.

THE Design of Writing these *Contem-*
plations, is to convince *Atheists* of the
 Wisdom, Power and Goodness of
 GOD, the Maker and Ruler of all
 Things; and *Infidels* (who indeed ac-
 knowledge a God, but reject the Authority of
 the Holy Writings) that the Scriptures are of a
 more than Humane Original; and so to represent
 to both of 'em THE RIGHT USE OF THE
 CONTEMPLATION OF THE WORLD.

The Methods we have made use of to prove
 the same, are only taken from the *modern Observa-*
tions, and *probable Discoveries* in *Natural Philosophy*,
 without laying down any bare Hypotheses; since
 in the Things of natural Knowledge we have no
 farther Foundation for Arguments than we can
 produce Experiments: Upon which you may
 consult the Writings and Plans of the *Royal Aca-*
demies and *Societies*, and of the most famous *Ma-*
thematicians among them.

The Reason why I have not made use of the
Metaphysics, &c. will appear in the *Preface*, Sect. 27.

While I was writing this, the *Arch-Bishop of*
Cambray's Book fell into my Hands; and while I
 was composing the *Preface* I met likewise with
 Mr. *Ray's* Book, translated into *French*; and was

ij *The AUTHOR's Epistle*

moreover inform'd (tho' I don't understand the Language) that Mr. *Derham* had published another Book in *English*, wherein he largely proves the Being of a God upon the same Foundation. It was very agreeable to me, to see and observe, that this Way of Proof, which I have always esteemed the strongest, was likewise embraced by such Great Men; in which, after all that is writ upon it, there still remains abundance of Matter to convince the unfortunate Philosophers of the Perfections of their Great Creator; and there will still remain enough to latest Posterity.

The Manner of *proving the Divinity of the Holy Scripture from natural Phenomena or Appearances*, which we here set before you, has not, that I know, been ever done before in such a Method. I hope, however, that the same may be of Use both to the *Atheist* and *Infidel*, because both those are wont chiefly to exercise themselves in the Study and Knowledge of Nature.

The general Method of convincing both of 'em, is more largely represented in the following *Preface*, *Sett.* xxix, xxx and xxxi.

I write in the *Low-Dutch* Tongue, to the End that I may be more useful to my own Countrymen; and especially, because that Tongue has been often abused in Publishing and Dispersing *Atheistical* Books.

The Order we follow can in some Manner be learned from the Heads or Contents of this Work; tho' I have not confined my self very strictly to that which has been pursued by many others upon the same Subject.

Those who will read this Work as an *Experimental Account of the Knowledge of Nature*, must not be offended at what we call the *Convictions*, which they frequently meet with, because our Design was not to write a Body of *Physicks* only, but

but to bring the Erroneous into the right Way; and by turning their Thoughts, after this manner, to the *Knowledge of Nature*, to lead them on to the true Notions of the *Deity*.

The able Mathematicians may perhaps think, that I ought to have proposed the Experimental Demonstrations, for Instance, of the *Power of the Muscles*, and of the *Hydrostatical Laws in Fluids*, &c. in a more Mathematical Manner, or else barely related them without any farther Proofs, and so to have made the same Conclusions, without so much Trouble, and so many Figures: But they must be pleased to know, that I have deduced those Demonstrations as far as it was possible for me, by *Experiments* only, and not as the *Mathematicians* are used to do from *Establish'd Laws of Nature*, to the End that I might be the better understood by such as know little or nothing of the *Mathematicks*. I was indeed at first of a different Opinion, and had already prepared the whole Work without any Figures, and without Proofs, the Grounds of which were nevertheless very obvious to *Mathematicians*. But forasmuch as a certain Learned Gentleman, and after him several others objected, that if I did proceed in such a Method, many would think that what I should advance in some Cases, was more incredible than true; and that in such great Matters one ought to bring at least as much Proof as would be necessary to confirm the Truth of one's Positions: I have therefore chosen to go on in that Way. This has likewise been the Reason why this Work, which I was forced to enlarge and alter in every Part almost, has seen the Light several Years later than it ought to have done, especially since my other Affairs have continually obstructed the same.

They who upon good Grounds do acknowledge a God, and the Divine Origin of the Holy Scriptures,

ptures, will here find sufficient Proofs of their Confession ; and those who are weaker, may likewise, I hope, be confirmed in those Truths against any Temptations.

But before I conclude this Address to my Reader, I must entreat those *unhappy Philosophers*, those *wavering and doubtful Persons*, those *Infidels*, and much to be lamented *strong Minds*, for whom this Work is chiefly calculated, that they would come prepared to consider the same, not so much with an acute, as with a serious Judgment, and decent Respect for so momentous an Enquiry; and not so much to observe what Difficulties may occur in some Particulars, as whether there is not something in such a Number of Things as may serve to convince them of the Perfections of their Maker, and of the Authority of his Word. If they proceed in the first Way, the strongest Proofs will be of no Use to them; but if they fall into the latter, one single Fact weighed by a Mind in earnest, and disposed to learn, may, by GOD'S Blessing, convince them of their Errors.

The *Thetical Way*, which is only made use of here for their Conviction, must not appear imperfect to them, as if it did not sufficiently confute their Sentiments; but let them compare it with their own Positions, and judge themselves, whether a Proof deduced from certain and actual Experiments, which is the Case here, ought not to be more convincing, than that which is grounded upon naked Ideas; which, without any actual Experience to support them, are arbitrarily advanced for Notions of things really existing; and that their Philosophy is only built upon this latter Foundation, they themselves must know. Accordingly, the Sophistical Arguments of those Atheists, and the not only false, but horrible Consequences flowing from their Opinions, have been already

fully expos'd by divers eminent Persons, to whose Writings we refer you.

If there should be any thing among all these Contemplations, in which, according to the Opinion of the Reader, I may have been mistaken, and have not rightly represented the Properties of the Natural *Phænomena*, let him pass it over, since he will not be able to say the same of all the rest; and in case he allow one single Proof to be strong enough among so many as are here brought together, or of those whereof the farther *Contemplation of the World* may yet suggest a much greater Number to him, that alone will be powerful enough to convince any Man that argues rationally, of the Being of a God, and of the great Origin of his Word; since one Demonstration proves as strongly as several, though more do strengthen the Conviction.

Neither let the Quotations of Scripture-Texts, in these Discourses, make you reject the whole Work without reading it, as many are used to do when they meet with them in any Books, since the Divinity thereof is not here supposed but proved; and that some of them serve to shew the Wisdom and deep Knowledge in Nature of him that inspir'd them; and others, to convince you that no Man, tho' never so understanding, nor any Impostor tho' ever so cunning, either for Political Reasons, or otherwise, was capable to produce in those Times such things as we find written therein, from whence you may easily conclude who has been the Author of them.

Let not the *Atheists* and *Unbelievers* conceive a Prejudice against this Work, since they may learn not only from the Title, but from those sincere Assurances we hereby give them, that we did not write it out of the least Hate or Contempt of them, but from a hearty Sorrow for their

miserable Condition, and only in order to their Conversion; for which Reason I have commonly made them themselves the Judges of the most part of my Conclusions: I therefore only intreat them that they would pass their Judgment upon what is here submitted to it, without that deplorable Resolution taken up by many of those who call themselves *Strong-Minds*, or *Free-Thinkers*, not to acknowledge the Being of a God.

One of these Positions must be irrefragably true (it being impossible to lay down a Third) either that, according to their Opinion, all Things in the World are govern'd by *Chance*, and by *necessary Laws*, without the Intervention of an Intelligent Being, and that the *Christian Bible* is composed by *Cheats* and *Impostors*, who had no other View but their own Advantage; or else, that the *Holy Scriptures* are given by a God that *Governs* the *World*, and who will require an Account from those Creatures whom he has endued with Reason, how they have used the same. *Let them therefore consider how much it imports them not to be mistaken in those things whereon their eternal Welfare or Misery depends; and let them judge whether it be not at least as true, that they and the World are made by a wise God, as that a Clock, or any other ingenious Piece of Workmanship, does prove the Skill of the Maker.* Upon all which, if they seriously contemplate, they will tremble at their own Notions: And since it is a Matter of Fact, and not a meer Speculation that is in question, and ought to be examined, whether it be not necessary to enquire into the Things themselves, without relying upon naked and atheistical Notions; 'tis for this End these *Contemplations* are written. May the Almighty God, who alone can over-rule our Minds and Thoughts, enforce these and other Proofs, in which the whole World abounds!

T H E



THE
P R E F A C E,
OR
I N T R O D U C T I O N,
TO THE
Following *Contemplations* of the WORLD.

SECTION I. *The true Difference between Atheists,
and those that fear GOD.*

IT is hardly credible, that there were ever any Men, who had not quite lost their Understanding, so foolish and unreasonable as to deny an *Eternal* and *Self-existent Being*, and to maintain that there has been a perfect State of *Inanity* or *Nothingness*, in which there were neither *Creator* or *Creatures*, for even the most Famous among the Ancients, and *Spinosa* himself among the Moderns, tho' they may justly be rank'd with the *Atheists*, have yet acknowledged an *Eternal Being*.

The great Difference therefore between *Atheists*, and those who confess and fear a *God*, is not whether there be such a Being, which from all Eternity has subsisted by himself (for that is owned by them all, at least by all that I have ever heard of) but whether this Eternal Being is also *Wise*, *Powerful*, and *Merciful*; and whether He has made all things according to his own Pleasure, for certain Ends and Purposes, and does continually direct and govern the same.

It is true indeed, that those miserable Wretches find themselves obliged, in some Manner, to confess his *Power*, were it only from their daily observing, with their own Eyes, what great Bodies are moved in the Heavens with an unspeakable Swiftneſs; and perhaps also, they might own his *Goodneſs* and *Mercy*, if we allow them to explain it in their own Sense, and to ascribe the Goodneſs of this Being only to the happy Qualities of Things, making use therein of their own Understanding, by which they think they are able to convert most Things that occur to them in the World to their own Advantage, and to render them subservient to their own Necessities and Pleasures: But with great Difficulty will they allow, upon their Principles, that this Eternal Being is *Wise*, and orders all Things according to his own good Pleasure; because such a Concession would be entirely inconsistent and contradictory, as well to a *meer Chance* as to all the *unknown Laws of Nature and Necessity*. This is also the only Foundation of their continual Uneasiness and Terror; since if this Being is *Wise*, and knows that they endeavour blasphemously to rob him of his Attributes and Perfections, they may easily conclude what will be their Reward hereafter.

That

That this was likewise the old Question in former Ages, may be inferr'd from the Writings of *Cicero* about it; where the Disputations of the Philosophers, by him introduc'd, do not so much turn upon the *Existence* of a *God* (meaning thereby such an Eternal Being) as concerning the *Nature of the Gods*. It may therefore seem strange, perhaps, to those who from their Youth upwards have been so happy as always to acknowledge and reverence *GOD*, for their Almighty Lord, Maker, and Preserver, out of a Conviction of his adorable Perfections, to hear that there can be found a Set of Men, who owning an Eternal Being, or the Existence of a *God*, do nevertheless consider him as deprived or divested of the above-mention'd Attributes: And yet that both the former and latter Times have swarmed with such deplorable Genius's, is too well known to fill this Book with the Relations of them. We shall therefore satisfy our selves with acquainting the Reader, that the following *Contemplations* are expressly calculated to bring these unfortunate Men, if it be possible, to better Thoughts.

SECT. II. *In order to bring Atheists to Reason, it is necessary to inquire into the Causes and Remedies of Atheism.*

THAT we may therefore take the true Methods to arrive at this great End, it seems necessary in the first Place, seriously to enquire what are the real Causes that many fall into such deplorable and irregular Opinions concerning this Tremendous and Eternal Being; and when we have come at the Knowledge thereof, to find proper Remedies to prevent the same.

But the Reader is desired to take Notice, that we do not intend to treat of this Matter in its utmost

utmost Extent; we shall satisfy our selves only to collect such of the Causes of modern *Atheism*, which we have experimentally observed to prevail over the Minds of these Impious Disputers, and from thence suggest such Means, as the same Experience has taught us to apply with good Success against this deplorable Evil.

SECT. III. *The First Cause is Inordinate Self-Love.*

THE first Cause therefore, and which mostly prevails in the Nature of Men, is usually the *Passion of too extensive and inordinate Self-Love.*

From hence only it is that Men desire to gratify their Inclinations, and to be in Subjection to no body; and if they cannot be exempted altogether from the latter, they wou'd have it be no other kind of Subjection than what is agreeable to their Carnal Appetites. Wherefore, hearing that there is a G O D, and that he is Just and Holy, and will be obey'd by them in all Things, and will certainly punish those his Creatures that refuse to acknowledge his Power, they earnestly wish to be entirely freed from it.

This induces them to turn a deaf Ear towards all the Convictions of such a Being; and forasmuch as their Consciences, in spite of all their Endeavours, will not suffer them to be easy, they are continually seeking out for Arguments, whereby they may persuade themselves of the contrary; and so stifle the dreadful Remorses of such their resisting Consciences. For these Reasons did the blind Heathens ascribe to their Gods, *Passions* and *Inclinations* like those which they felt in themselves; pretending that those Gods delighted in *Drunkenness*, *Fornication*, *Adultery*, and other irregular Affections.

To

To look for no farther Proof of what has been advanced, let every Man who has been so unhappy as to hunt for Arguments to darken and blot out of his Mind the Knowledge of the Perfections of his Creator, retire into himself, and examine, whether if that which is received by Christians for the Word of God, and in which his Will is contained, should allow him to abandon himself to all his Inclinations in this Life, and should promise him the Enjoyment of the like Pleasures through all Eternity, he would not endeavour with as much Zeal and Diligence to find out Reasons whereby to convince himself, and every Man besides, that there is a *God*, and that the *Bible* is his revealed Word, as he now Attempts to make himself and others believe that the same is false. There is, however, an innate Desire in every Man to become happy : Does he expect to find this in the Knowledge of a God ? then will he extend his Desires that way : But perceiving, that by the Acknowledgment of a Supreme Holy Being, he would consequently be obliged to renounce his sinful Pleasures, he will wish that there was no such thing as such a God ; tho' he dares not own the same, least he should be found out by others for what he really is, a miserable *Atheist*.

I appeal for the Truth of what I have here said to those Men who have ever lived in these sad Doubts and Uncertainties, and in the mean time followed their Passions as far as they could, without incurring the Punishment of the Temporal Magistrate, and without Prejudice of their good Name or Estate, but have at last attained to a better Mind. It is not necessary to produce Examples of those who after their Conversion have openly avow'd the same, tho' I could easily do it.

SECT. IV. *The Means to prevent this inordinate Self-Love.*

Now since this whole Mistake is nothing else but a Passion that hurries them away without the least Foundation or Shadow of Reason, many of this kind of *Atheists* are reduced to the right Way, when GOD (who in all these Cases must be acknowledged to be the first Cause) shall please to sanctify the Means that are used thereto ; which, besides the Increase of Years, that often calms the impetuous Passions of Youth, do likewise sometimes consist herein, to wit, that they be brought to a right and serious Consideration of the *Wisdom, Power and Goodness* of God, which undeniably manifest themselves in the *Contemplation* of the *World*, and the Government of all Things in a multifarious Manner, to such as are not resolved to remain wilfully Blind ; especially, if the corrupt State of themselves, and of all Mankind, and the Vanity of those Things upon which they bestow the Name of Pleasure, be set before them in a proper Light ; and especially that unhappy Condition in which all Men would find themselves, if, according to their own Opinion, the World were govern'd either by meer Chance, or by the Laws of blind Fatality. Finally, how dreadful would it be for them in case their deplorable Notions (for I cannot bestow a better Term upon them, since no body can prove them) should be entirely false. By which Considerations, a lower Value for present, and a greater Concern for future Things, would be produced in their Minds ; which being opposed to their former Passions, might contribute to extinguish the same, and awaken in them such serious Thoughts, as sometimes are alone sufficient to make them change their Opinions. SECT.

SECT. V. *The Second Cause is inordinate Ambition.*

THE second Cause of *Atheism* is another Passion, consisting in an *irregular Ambition*, which arises from the same Source of *Self-love*, by which some, having once abandoned themselves to the Defence of such unfortunate Sentiments, fancy that they ought therefore to pass with other Men for Persons wiser, and of greater Understandings; and so they bestow upon each other the Appellation of *Esprits Forts*, that is to say *Strong-Minds*, or *Free-Thinkers*; being, as it were, desirous to shew thereby, that they are such stout and courageous Men, as are not to be terrified with vain Fears and Bugbears (as they term it) like the Vulgar and Childish People.

This is one of the highest Steps to which *Atheism* can attain, and indeed it cannot well climb higher; because, when it is once arrived to that pass, it does not only slight all Convictions, but so long as this Passion and inordinate Ambition continues, compels Men necessarily to reject them, and consequently to remain altogether incurable. For whereas the first sort of *Atheism*, which is only founded upon the Enjoyment of Pleasures, may be silently opposed and conquer'd as soon as any contrary Arguments begin to make an Impression, this last has moreover this Obstacle and Hindrance in the removing it, that those who have once maintain'd it, altho' they should change their Mind, are afraid of losing their imaginary Esteem, and the Honour of a Superior Wisdom and Knowledge, and of being henceforwards accounted by those that know them, not only Cowardly and Unconstant, but likewise Men of mistaken Judgments: It being commonly the way of these conceited Strong-Minds

minds, or Free-Thinkers, to speak contemptuously of all that see their own Errors, and have Virtue enough to forsake them. Now how powerful the Fear of Contempt is over some Men who have a great Conceit of themselves, we are taught by daily Experience in many Cases; insomuch, that this unhappy Sort of Creatures have been often observed to break forth into dreadful Blasphemies, only to give a Proof of their greater Knowledge and Penetration, and to avoid the suspicion of speaking against their Consciences, and of dissembelling their just Fears.

SECT. VI. *The Remedy against this Evil.*

I HAVE seldom seen any Humane Means made use of with Effect against those who will not be convinced; since this kind of *Atheism* is attended, for the most part, with great Ignorance; and that those miserable Wretches who are tainted with it, can be seldom brought to listen carefully to the Arguments objected against them; being accustomed to answer the best and strongest Proofs with Contempt and a scornful Smile, not judging them worthy of a better Return from their superior Understandings. Yea, whatever may be the Occasion of such an excessive Hardness and Stiffness of Heart, it is visible that they lie under a dreadful Judgment of that GOD whom they have so unrighteously blasphemed; and so far as one may guess from Circumstances, do often continue so to the End, unless the same merciful GOD be pleased to take Pity on them, and make them unconceivable Miracles of his Grace.

Among such I knew one, who having been advised by a Friend (for he was deaf to all other kind of Proofs) seriously to consider himself,

The PREFACE.

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self, his Soul, and Body, and all that happen'd in the World round about him, began to perceive that it was hardly to be believed, that he himself, and all besides him, could be made and govern'd by any thing but a Being endowed with great Wisdom: So that a little while before he died, he heartily thanked his Friend for the Counsel he had given him, and detesting his former wicked Thoughts with a Flood of Tears, he continued to his Death to beg Forgiveness of that GOD, whom all his Life-time he had refused to acknowledge; praising, with his last Breath, the unexpressible great Mercy of his Divine Majesty, who had vouchsafed to look upon such an abominable Creature (that had deserved nothing but his Wrath and Vengeance) with the Eyes of Mercy. I have known others of this kind, some of whom have in a harden'd Manner drowned themselves; others, that have taken Poison, and the rest ended their Lives in the utmost Despair upon their Sick-Beds.

SECT. VII. *Concerning the Death of Spinoza.*

UPON this Occasion of mentioning the miserable Deaths of several Atheists, I cannot forbear to take Notice of what has been related, and with great Truth, as far as I could discover, touching that of *Spinoza*, that he ended his Life in Solitude and great Tranquility, without manifesting any external Signs of Uneasiness. This I know seem'd strange to some Weak but Pious Men, who had either seen or heard of very different and most dreadful Judgments of GOD against some that had thus denied him; and the Followers of this same *Spinoza*, took an occasion from thence to think, that the Opinions of their Master were not so unjustifiable.

able. But for the Satisfaction of the former, they ought to be told, that GOD working with Freedom, does not always punish Sins so visibly in this Life ; and as for the latter, if they have been conversant in the Writings of that *Atheist*, they may observe from thence, that *Spinoza* is not so much to be looked upon for a learned Disputant as for such a sort of an *Atheist*, who with or without Conviction, was resolved simply to adhere to his wicked Opinions ; because, as he thought, they would make him pass his Life more agreeably.

I would not have it thought that I say this of him out of Prejudice, but refer to his own Words, in his 34th Letter to the *Heer van Blyenbergb* ; where he says, first, that he does not understand the Holy Scriptures, and entirely acquiesces in the Suggestions of his own Understanding ; and then (instead of proving the Certainty thereof, which would have become a true Philosopher to have done upon such an occasion) he proceeds thus, in a very unworthy Manner, to speak to some Body that is seeking after Truth : *And altho' what I have already advanced concerning the natural Understanding, should appear to be false ; yet I am happy, whilst I enjoy my Opinion, and pass my Life easily, merrily, and pleasantly, without Tears and Sighs, &c.* Now let wise Men judge, whether these Words shew a Philosopher seeking after Truth, or an obstinate *Atheist* that will not be convinced, least it should spoil his Mirth. It cannot therefore be denied, that GOD may suffer a stubborn Blasphemer to fall away so far, that by persisting a long time in his Errors, he becomes at last entirely blind, and so remains, till the impending Wrath of GOD shall open his Eyes.

It is, moreover, very certain, that to the end he might not be disturbed (I mean *Spinoza*) he would

would not admit of any Discourse, whilst he lay upon his Sick and Death-bed; with any Body about the State of Men after this Life, and the Certainty or Uncertainty of his own Opinions; which also does not look like the real Convictions of a true Philosopher: For tho' his Judgment might be so weaken'd by the Violence of his Sickness, that he could not well weigh nor answer the Reasons and Objections that were brought against him to his own Satisfaction; it was nevertheless true, upon his Principles, that he would not therefore be the more unhappy after his Death; but only that he could not have flatter'd and delighted himself with the Honour of passing for a greater *Free-thinker* than other Men.

Lastly, I may here add, that one of his most particular Friends and Disciples (well known to me in my Youth) who always adhered to his Opinions, and maintain'd them, when he durst, with great Acuteness, being a Man of very good Parts, lying upon his Sick-bed, and remaining there in a long Silence and Indolence, in Imitation of his Master, did at last burst out in these dreadful Expressions; *That he now believed all that he had formerly denied, but that it was too late for him to hope for Mercy.* This was related to me, concerning the dreadful End of this Man, with all its Circumstances, by a certain learned Gentleman, who knew that I having been acquainted a great many Years with the Opinions of that unfortunate Creature, and hearing of his Death, should be desirous to be informed of the Circumstances thereof.

Now whether the Followers of *Spinoza*, after having well consider'd all that has been said concerning the last End of their Master, have any Grounds for their Indolence and Indifferency, I

leave it to themselves to consider; provided they will do it without Passion and Partiality.

SECT. VIII. *The third Cause is Ignorance.*

A THIRD Cause of these deplorable Opinions seems to be, in some Men, a *downright Ignorance*. Accordingly I have met with some, who having never exercised their Understandings in examining Matters, have blindly followed their Inclinations in all things, so far as their Opportunities, which were few enough, would give them leave; and who being asked, what they thought of the *World*, and of its *Beginning*? openly denied that a God had made it.

I knew one of this sort, who, after having abandon'd, himself to Drunkenness for many Years, and passed his ignorant and brutish Life in these destructive Notions, died in the same; at least it appeared so to them that attended him during his last Illness, and that related it to me.

I met also with another, that might justly be ranked among the Number of these ignorant Persons, who, tho' he was outwardly a regular and sober Person, yet when he was in the Company of those that were not very averse to his Opinions, did not scruple to speak out plainly, and to affirm, that every thing *was from Nature* (this was his Expression) *so as it is*: And when he was pressed more closely to explain himself, alledged no other Reason, than that it appeared so to him, and that he could not conceive it otherwise; affecting, at the same time, under this Darkness and Ignorance, a certain Haughtiness, as if his Understanding was much superior to that of others.

SECT. IX. *Means to prevent this Evil.*

Now, for the Conversion of this Sort of *Atheists*, since the best *Metaphysical* Arguments make no Impression on them, forasmuch as they do not conceive them, nor will give themselves the Trouble to study them, nothing seems to me more useful than to set before them such Proofs as are only founded in those common Experiments, obvious to every Man's Sight; and I know that one of this last Sort, who could not easily be induced to discover any Weakness or Doubts in his Opinions, was thereby obliged to acknowledge, that such Proofs made him a little uneasie.

SECT. X. *The fourth Cause is too great a Conceit
of one's own Wisdom.*

THE Fourth Cause of *Atheism*, as far as my Observations and Experience reach, proceeds from a too great Conceit of our own *Wisdom*, and from an implicit admitting that to be *Truth* which we are wont to deduce from our own *Ideas* or *Notions*. And some Men are apt to advance such their Notions with great *Arrogancy*, as well concerning the *Divine Attributes* and *Properties*, as about the smallest *Appearances* in the *Creatures*. In short, they except nothing, and pretend to reduce every thing to an infallible Rule of Possibility and Impossibility, Truth and Falshood, Good and Evil.

This is the most dangerous Kind of all: *First*, Because they deny every thing that they do not conceive; and therefore all Divine Revelation (which is above their Understanding) is not only rejected by them, but ridiculed also. *Secondly*, Because they have the greatest Opportunity to support

their Errors with specious and plausible Arguments, and to evade the Force of those Objections that are brought against them, which they immediately make use of as soon as their Adversary commits the least Oversight or Blunder. *Thirdly*, Because many of them, in their Conversation, do assume an External Appearance of Morality, and other Social Virtues, whereby they sometimes acquire a certain Esteem with the Ignorant, which may be of dangerous Consequence; the rather, because divers of them having learned the Elements of *Euclid*, *Algebra*, and other speculative Parts of the *Mathematicks*, pass amongst the Unknowing for great *Mathematicians*; which Title does really no more belong to them, than that of a great Philosopher to one that understands nothing but a little *Logick*; since People may be very well experienced in these Ideal or Notional Sciences, and yet be Masters of very little, or no Knowledge at all, in Things that actually exist and come to pass.

But we must not from hence conclude, that such noble Studies do of themselves lead those miserable Men into such erroneous Opinions; for these in many Cases, open the Way to the *Discovery of the Wisdom of God in the Works of the Creation*, to which we could not otherwise attain: On the contrary, they are exceeding useful, unless when misapply'd by these half-learned Men, who being puffed up with a little Knowledge, fancy they know every Thing, and despise all those who do not just understand as much as they themselves, about *Lines* and *Quantities*, tho' they be much wiser, and more judicious in other Kinds of Learning.

SECT. XI. *Spinoza briefly confuted.*

THUS we find at present, that in order to make even *Atheistical* Writings to pass for uncontroverted Truths, the Authors thereof have endeavour'd to give them the Form of Mathematical Demonstrations. A remarkable Instance of which may be seen in the Book of *Spinoza*, which has for that Reason gained so much Credit with many of these unhappy Persons ; because those who do not rightly understand the *Mathematicks*, judge from the External Appearances, that what is laid down therein is deduced from just *Mathematical* Principles.

Perhaps we may hereafter find an Opportunity more tully to shew the Mistakes that are there advanced under the Name of *Demonstrations*, when we shall compare 'em with such as are truly *Mathematical*.

To say a Word or two thereof *en passant* :

1. There are two Kinds of Objects, about which the *Mathematicians* do treat or employ themselves, *viz.* Ideas simply considered as such, and Ideas of Things really existing ; that is, to speak more clearly, *Mathematicians* discourse either only about their Ideas, or else about Things that are really existing out of their Ideas.

2. The first Manner is seen in the *Speculative Geometry*, such as the Elements of *Euclid*, *Algebra*, &c. where they conceive a Point as something that has no Parts, a Line without Breadth, &c. So likewise they here consider Magnitudes, which have more than three Dimensions, &c. which every Body knows are only certain Ways of our Conceptions, having no real Existence out of them.

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3. The second Kind of Object occurs in *Astronomy*, *Opticks*, &c. where things are considered, which, besides our Ideas of them, have a real Existence in themselves.

4. The Foundation of the First, besides *Axioms*, are *Definitions*, in which they describe their Ideas, without troubling themselves whether there is any thing really existing that agrees therewith: Instances of which we have just now given. Accordingly it is with them a Truth, that *the three Angles of a Triangle are equal to two Right ones*, and wou'd still be so altho' every thing in the World were circular, and that there were not really such a Thing as a Triangle.

5. The other way is founded upon Experiments and Discoveries, which either they themselves, or other credible Persons make of Things which are out of their Ideas, and something more than mere Conceptions. Thus a good *Astronomer* lays down for the Foundation of his Science, that which he, or those whom he can believe, have experimentally discover'd, namely, that there is really such a Thing as a *Globe* of the *Earth*, a *Sun*, a visible *Moon*, five *Planets*, some of which have their *Satellites*, or Bodies circulating about them, and a great Number of fix'd *Stars*; but does by no means extend his Imagination or Fancy to the Supposition of other Worlds, and other sorts of Bodies; as for Instance, that there are ten Suns, a hundred Moons, a thousand Planets, and a very few fixed Stars; of which imaginary Worlds he might nevertheless bring a great many Proofs, which according to the first Way of arguing, we may allow to be Mathematical enough, but when adapted to the Things themselves, would appear to be entirely false.

6. Now those that have read and understood *Spinoza*, are sensible that he only lays down his own

own Ideas and Notions for the Foundation of every thing, which therefore needs not to be farther proved here: From whence it may appear to every one, that he applies this manner of discovering Truths preposterously to Things really existing, of which true *Mathematicians* never make use, but only about their own Ideas: wherefore the whole Series of so many Hypotheses and pretended Demonstrations in *Spinoza's* Book (tho' he should argue rightly upon those Principles of which, however, the contrary may be proved in many Cases) do represent nothing else to us than only the Properties of those Imaginations or Conceptions which that unhappy Author had formed in himself; nor can any Man thereby conclude any thing more from the Things themselves than an Astronomer can do, who advances his own Fancies for the true Structure of the Heavens.

7. So that from this Mistake alone the Weakness of all *Spinoza's* Arguments appear at one View, and how little his Way of Demonstrating agrees with that of true *Mathematicians*.

SECT. XII. *The Remedies against this Fourth Cause,*

BUT to return from this Digression. Since these unhappy Philosophers ascribe so much to their own Understanding, and do exert their whole Strength to oppose the Weight of all *Metaphysical* Arguments, tho' they are supported by strong Reasons; the only Way that I have ever seen used with Success to overthrow their proud Fancies, that they can conceive every thing, and to shew them the Narrowness of their Understandings (which is particularly necessary to their Conversion) is this: Let them be brought into a *Chymical Laboratory*, or other Places where People are wont to make Physical Experiments, such as are not

commonly known to every Body, and let them be asked what will be the Result of such, or such an Operation, pursuant to their own Notions and Conceptions? In which, if they mistake, and Things appear quite contrary to what they expected, they can have no Subterfuge or Evasion, but will be compell'd to acknowledge, that their Understandings have been very little conversant upon Objects really existing: And in case they themselves are versed in natural Experiments, let them be desired to contemplate, without Prejudice, the Manner how every thing they see comes to pass, and to think whether the Power and Wisdom of the Great Creator and Ruler of all Things, does not appear as incontestably in them, as the Judgment and Skill of any Artificer in the Machines that he has invented.

SECT. XIII. *The first Steps to Atheism are Prejudices.*

BESIDES the above-mention'd four Causes, there do occur to me other Steps or Inducements to *Atheism*; which tho' they cannot properly be esteem'd *Causes*, as the former, yet they are used by many as Steps towards it; and tho' they do not always bring Men to deny, yet they do at least tempt them to doubt of the highest Truths.

The first Sort of these are our *Prejudices*, some of which we bring into the World along with us, as others proceed from the Slavishness of our External Senses. Thus Men fancy, for Instance, that the Sun is no bigger than a Trencher, or little Dish, and that its Distance from us is very small: In the same Manner the Planets appear to us as little contemptible Things. This being deeply impressed in our Minds, tempts us to look upon the Greatness of God with very small Respect or Reverence; since from such Appearances
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we judge there was very little Power necessary to form and govern them: Whereas, if we did (as we ought to do) consider the World in its immensurable Expansion, the Sun as a Globe of Fire, of a most amazing Bigness, and the Planets as so many thousand times bigger than this whole Earth, they would excite in us quite other Sorts of Conceptions, and make us stand abashed at the great Power of our adorable Creator and Ruler.

Another *Prejudice*, which hinders us from observing the Wisdom of God in the Direction of the visible World, is, that when we cannot see either *Bodies* or *Motions*, we are presently apt to fancy that there is nothing either of Body or Motion but what we can see with our own Eyes; for believing that that which is in Rest will always remain so, and that nothing else is requisite to continue it, it seems to us as if neither Power nor Direction were necessary thereto; and that Fancy insensibly leads us either to deny altogether, or at least hardly to acknowledge any Divine Providence in those Things and Places. Thus do many imagine, that in a Chamber, for Instance, which is full of Light and Air, all Things are still and quiet, and consequently that there is no Want in that Place of any Power and Wisdom to preserve us from Accidents: But if one were to represent to such Men the incredible Strength of the Air surrounding them, and that without the Intervention of a Wise and Powerful Being, which continually restrains its resistless Violence by a Counterpoise and Ballance of Force, they would be crushed to Pieces in an instant: And so if they were made to conceive the terrible Motions of Light, which unless it were govern'd by certain Laws, by which its Rays are separated and scatter'd, would, in the Space of a few Minutes, put this whole Globe
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of the Earth in a devouring Conflagration; who could doubt, if he had the least Spark of Reason in him, that he has not from hence the justest Cause imaginable to praise and extol the *Greatness, Power and Wisdom* of a God, who only preserves us from all those Dangers, and hinders us from perishing in so miserable a Manner!

SECT. XIV. *The Means to cure Men of these Prejudices.*

Now in order to be cured of these *Prejudices*, we are taught by what has been already said, that it is necessary to enquire experimentally into the true State and Nature of Things, and afterwards to form a right Notion of them from those Proofs which are drawn from undeniable Experiments, and frequently to meditate upon the same; this will make us, as it were, feel with our Hands the Power of the great Ruler of all Things, if we do but carefully attend thereto.

SECT. XV. *The second Step, the absurd or wrong Manner of describing Nature.*

THE second Inducement or Inlet to *Atheism* (tho' upon many Occasions it is in itself useful and necessary, but by an imprudent Application serves to corrupt Mens Understandings) is an *absurd and false Manner of Philosophizing*, or rather of *Instructing any one in the Knowledge of Nature*; under which Head I refer, in the first Place, to such sort of Books as perhaps are not written with an evil Design, but which, however, if you will believe the Authors themselves, pretend to give a true Notion of the whole Frame and Construction of the World, and of all its visible and invisible Parts without Exception; describing,
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after their Manner, with as much Assurance as if they had been present, and were G O D A L M I G H T Y's Cabinet Council, how he made the World, how he put all Things together, and how he has produced and continued the Motion thereof; and (which I have often been surprized to hear from the Mouths of such as were otherwise Men of good Sense) even how every thing between the Circumference of the starry Heavens, and the Centre thereof, were made in the Beginning of the World.

N O W, if so be that any Man should fall into such an unhappy Opinion, as to receive for Truth all that he finds written in such Books, how can he do otherwise than believe, that there was no more Wisdom requisite to bring this glorious Frame of the World into such a beautiful Order as we see it, and to continue it in the same, than what the Authors of such Books were Masters of? And how far this may in time mislead a great many young and unexperienced Persons, and divert them from that Wonder and Reverence which is due to the endless Wisdom of G O D, it is easie to imagine, and some have found by fatal Experience.

S E C T. XVI. *The Inconveniencies of Deducing every Thing from an Hypothesis.*

To this wrong Way of Thinking may be ascribed the Manner of Deducing all the Phenomena of Nature from a certain Hypothesis. Now it will be very easie to shew, how many Occasions of falling into irreverent Thoughts of G O D's All-ruling Providence this imaginary manner of Philosophising furnishes Men with; since some Understandings observing that it costs them more Pains to comprehend any notable Mathematical Proposition, or to
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solve an *Algebraical* Question, than to represent to themselves the Causes and Operations of all that belongs to the visible World, upon the Foot of such an Hypothesis; the great Work of the whole Creation appears to them more easily to be conceived than some of the Inventions of the *Mathematicians*. From whence therefore a tacit Consequence is deduced by little and little, that towards the Construction and Government of the Heavens and the Earth, less Wisdom is required than what many Persons, whom they look upon to be great *Mathematicians*, are really possessed of; and this does proportionably diminish the Reverence which they ought to have for the Wisdom of their Great Creator; the Loss of which is oftentimes one Stone of Offence, upon which some of my Acquaintance have first stumbled, and afterwards fallen.

Those who have been intangled in such a Labyrinth, are wont zealously to engage themselves yet farther therein, and, against all the Convictions of contrary Experiments, to support their Hypotheses with all their Might; perswading themselves with a secret Pleasure, that without bestowing any Trouble or Charges upon Trials, their own Hypotheses will serve them for a true Key to open the most hidden Secrets of Nature: And to the end that they may not be brought into any Doubtings concerning the same, from this Observation, that there may be more than one Hypothesis, from which the same Effects are deducible (as is known in *Astronomy* and other Cases) many of 'em are accustomed to lay down this Maxim, *That an Hypothesis may be safely maintained to be the most true, because it is the most simple*: Which Argument is of much the same Force, as if any one seeing a Watch going in a Chamber, pretends to have rightly proved, that the same is moved by a
Weight,

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Weight, and not by a *Spring*, because the former of these appears to be the most plain and simple.

Finally, this Hypothetical Philosophy is so much the more prejudicial, that it necessarily obliges Men to fancy that they have attained to a fundamental Knowledge of even the most principal Things that occur in Nature; since every one must expect to be look'd upon as a compleat Fool, in case he presumed to find out an Hypothesis which was proper to account for *Phænomena* wholly unknown to him; so farasmuch as any Alteration in the *Phænomena* must likewise necessarily produce Alterations in the *Hypothesis*; and this cannot be done without occasioning too mean an Opinion of the Works of our Great Creator, and even of the Creator himself.

To disentangle themselves out of such a Labyrinth, more Pains are requisite than a Man who has never tried it can perhaps imagine; especially, if such Persons be pretty far embarked in these Studies. Every one who has had the Trial of it, knows how mortifying it is to give up an Hypothesis which he has believed and maintained for many Years to be true, upon which he has pored and meditated so many Nights, with which he has blotted so much Paper, and for the sake of it, ran thro' so many Books; and, lastly, by the help of which, he fancies to himself, that he is arrived to the Top of all Wisdom, or at least, that he shall soon reach it. He that has a mind to see an Instance thereof, let him peruse the Preface to the *Anatomy of the Brain*, by the Learned Dr. *Willis*.

S E C T. XVII. *The Remedies against this Evil.*

N O W, in order to prevent the being seduced by this manner of Philosophising by Hypotheses only, it is first necessary, that Men should not dwell too long upon those speculative Studies, tho' they should silently flatter us with the Fruitfulness of such Hypotheses, and the Representation of the Greatness of our Understanding; but we should give ourselves up to actual Experiments, not enquiring into the Opinions of Men, but into the Nature of Things themselves; and satisfy ourselves of the *Power* and *Wisdom* of the adorable Creator, after a quite different and more positive Manner; and learn how great is the difference between *knowing* any thing *Experimentally*, and *guessing* at it *Hypothetically*.

S E C T. XVIII. *Another Remedy.*

A N O T H E R Way whereby we may secure ourselves against the Evil Consequences of these kind of Studies, is, when we are asked about Things of which our Ideas are not sufficiently clear, to answer calmly, and without blushing, *I know not*; and by no means pretending by this, or that uncertain, or undemonstrated Hypothesis, to give an Account thereof, for fear of losing the Respect that belongs to us. This will prevent the naturally high Conceptions which we have of our own Understanding, from throwing Dust in our Eyes; and it is the true Means to make us think humbly of ourselves, and to contemplate with Wonder the Works of our great Creator.

I know very well how hard a Thing it is for one who has an Opinion of the Fame of his own Learning, and who has devoted himself to these Studies,

Studies, to be brought to a frank Confession, *that there is something which he does not know*; the rather, because this or that Hypothesis may seem always to furnish him with a Back-door to evade such an Answer. But tho' this be a little shocking at first, yet the Man who is truly knowing, will soon bring himself to confess, that there is such a Thing as an *Eruditum Nescire*, or a Learned Ignorance, *viz.* in such a one, who knowing at first what Great Men have pronounced about a certain Thing, yet can shew experimentally, that their Opinions are not to be received for Truth; and being himself asked about it, confesses his Ignorance without Reluctancy. This will by no means lessen the Esteem, which he has acquired by his Learning in the Opinion of wise Men; and yet will produce this Fruit, that quite different from many unhappy Atheists, who fall into Error, thro' a Conceit of knowing all Things, he will acknowledge, that the Wisdom of GOD, as it shines out in the Phænomena of the World, does far surpass his own weak Understanding.

SECT. XIX. *The Use of Hypotheses.*

WE would not, however, that Men should believe from hence, that we reject all Hypotheses as quite unnecessary; since, if they be properly used, they are of great Service in many Cases; not only because they reduce the Thoughts of an Enquirer into a more regular Compass, and hinder them from rambling out too far; but chiefly, because they are of a particular Advantage in directing the Judgments of young People, and setting them a Pattern how they may afterwards Discourse and Argue from Experiments; provided it be done with such Prudence and Caution as may lead them to make a just Distinction between
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the one and the other : Wherefore, it is commendable enough in those Persons whose Design and Duty requires them to direct Youth in the Course of their Studies.

Before I proceed to any thing else, I can't forbear adding in this Place, that in reading the Works of those Philosophers who pretend not only to describe the great *Universe*, even to the smallest Parts of it, with so much Assurance, but do likewise undertake to account for, and make known to the World the Original and Principle of all Things, I have often thought, that if those Gentlemen had not had more and better Opportunities of discovering how a Human Creature is born or produced than how the Universe or this Globe of the Earth are made; what strange and absurd Hypotheses would they have advanced upon this Subject; and without succeeding or guessing right in any one of their numerous Schemes, notwithstanding that every one might perhaps be supported by as many and as good Reasons as any of those concerning the *Universe*, which have no Foundation but in the Fancy of these Philosophers : Not to mention, that if the real Manner of the *Formation* of a *Human Creature*, as far as it can be known, were laid open to these Philosophers, without doubt some of 'em would tell us, that they could have discover'd a more simple, and consequently a more probable Hypothesis thereof : And others would imagine that they could easily prove that the true Manner of such a Formation ought by no means to be admitted; namely, that the *Fœtus* can live, like a Fish in Water, nine Months in its Mother's Womb; for they can demonstrate by uncontestable Experience, that nobody can live so many Minutes under Water. They who please to reflect upon
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these Matters with us, may judge from thence how little Dependance there is on meer, tho' ingenious and plausible, Hypotheses.

SECT. XX. *A Third Inducement to Atheism, to admit of no Final Causes.*

I Do not know whether I should not lay down this for another Step or Inducement to *Atheism*, viz. the Maxim that some have taken up and maintained, *That in Philosophising, no Notice is to be taken of previous Designs or final Causes.*

I do not here blame those Philosophers who affirm, that in the Study of Nature, where Men enquire how every thing *Is, Acts, and Moves*, the Contemplation of *Final Causes* have properly no Place; and I readily agree, that when one is ask'd, *How does such a Thing happen?* it is absurd to answer, *That it happens for such an End or Purpose.* But this is nevertheless true, that if such a Rule be admitted without any Restrictions, it may serve to mislead Men into a raw Conception, that all Things are made without a View or Design, and that *meer Chance*, or *unknown Causes*, take place in the World: Yea, the Question, *Why any thing happens?* or, *To what End it is serviceable?* ought not to be entirely banished out of Philosophy, as unworthy of great Understandings; tho' we should allow, at the same time, that it does not properly belong to that Part of Physicks which contemplates the operating Causes. This, I believe, every body will grant, who having enquired into Natural Things, has, with Pleasure, seen the Uses thereof, and the Service which they render both to the World, and to Men.

It is true, indeed, that in the Modern Philosophy, this is not taught abstractly from other Things; but as in *Pneumatics*, the Properties of Spirits; in *Physics*, those of Bodies; in *Mechanics*, the Laws of Motion; in *Astronomy*, the Properties of the Heavenly Bodies; in *Optics*, those of Light and Vision are handled; so it occurs to me, and I think not without Reason, (if one should treat expressly about the Designs and wise Ends of the Creator, and shew the same from the State of Things, and from their Uses) that a *Scopology*, or *Study of Ends*, would prove one of the most exalted Parts of Philosophy, and might contribute, not only to convince many (who otherwise forget God) of their Obligations, and just Gratitude to their Great Maker; but likewise to render Famous to all Posterity, such as have been diligent and successful in discovering new Uses of Things, tho' the Things themselves have been known long before. Thus we see, that *Harvey*, in the Discovery of the Circulation of the Blood, found out a Use that was never before known, of the Heart, Veins, and Arteries; so did *Malpighi*, of several of the Parts of Animals and Plants; so did *Borelli*, of the Instruments of Motions; whereby they have all of them render'd their Names honourable to future Generations.

SECT. XXI. *The Remedies against this wrong Notion.*

How much the Experimental Examination of the Creatures is useful to avoid the Evil Consequences of such rash Principles, the nice and exact Enquirers in this Age have shewn us; especially the Anatomists, who are wont, to all the Descriptions they have given us of Bodies, expressly

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presly to subjoin the *Ends* and *Designs* for which they are so composed, together with their *Uses*; and very often expatiate from thence, upon the *Praises* of the *Wisdom* and *Goodness* of that *Being* which has formed them; of which the above-mention'd laudable Gentlemen, *Harvey*, *Malpighi*, *Borelli*, and a great Number more, are illustrious Examples.

S E C T. XXII. *The Fourth Inducement is Disputes.*

TH E Fourth Inducement, which indeed does not of itself always beget Atheism, but yet insensibly leads to it, and even hinders Men from being convinced of the most Fundamental and Divine Truths, is those numerous Disputes that are started concerning them, and of which there is never any end.

This need not be proved to those that are acquainted with the Divisions among the Ancient and Modern Philosophers, who tho' they join perhaps on all hands, to defend the Being and Attributes of a God against *Atheists*, yet do not agree in (but frequently reject) the Arguments brought by one another to prove the same. By such continual Differences, (especially if Passion and ill Language be mix'd therewith) Men that are not settled in their Principles, are rendered yet more unstable and doubting; and there is too great a Haadle given to such as deny a God, to maintain, with some kind of Probability, that all that has been said and believed concerning Him, is not attended with so much Certainty as it ought.

SECT. XXIII. *Means to prevent the same.*

Now to the end that we should not be subject to those Disputes, and that a total Stop may be put to them, we shall here propose a Means, which we hope may seem proper for that purpose; which is seriously to set about enquiring, wherein the just Characteristick, or Mark of the Truth or Falsity of a *Proposition* or *Enunciation*, consists: For if People did but agree in this one Thing, they might, without any farther Caviling or Disputing, judge with Certainty of a Proposition, in case it was accompanied with the right Marks of Truth, that it was True; and if it had the contrary Marks, they might pronounce it False; and again, if those Marks were obscure on both Sides, they would declare it doubtful and uncertain.

But since it is more to be wish'd than expected, that the Disagreement among Philosophers, about the Characteristicks of Truth, will ever be entirely laid aside; the best way that I can think of to avoid, and put an end to Disputes, is to make use of such Proofs of the Truth or Falsity of a Proposition, that have their Foundation, not so much in Arguments, as in undeniable Experiments, as often as it can be done.

Men must be well confirmed in what has been here laid down, since we have a clear Proof thereof in our Modern Physicks; it being known to every one, at least allowed by the most Learned, that in order to be assured of the Truth of a Position in this Science, the same must be demonstrated by Experiments; and it has been found, that the greatest Men of this last Age have allowed Experiments to be the only Characteristicks of Truth, and that an end has been
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put by them to many Disputes, and that very few new ones have arisen in Natural Philosophy, which have not thereby been quashed almost as soon as they appeared. Thus all the Debates, Whether the Blood circulates or not? Whether Water rises in a Pump by the Pressure of the Air, or not? Whether Nature can suffer a *Vacuum*, or empty Space, or not? and a great many others, about which Men have so long wrangled, are now entirely removed by unanswerable Experiments; and the Truth of the former, and consequently the Falsity of the latter, are proved even by *Ocular Demonstration*: And since the Motion, or Rest, of the Sun, has not yet been determined by any Experimental Proofs the most famous Astronomers have yet made, that must be rank'd among those Things that are to be accounted uncertain: But of this we shall treat more largely when we come to the Contemplation of *Unknown or Undiscover'd Things*.

SECT. XXIV. *The Abuse of Academical Disputes.*

BEFORE I quit the Subject of Disputes, I find myself obliged to represent, with great Submission, to those Gentlemen in whose Power it is to reform those Abuses, (in case this Book should ever have the Honour to be perused by them) something that may prevent the same; for tho' Disputes may have been at first established and made use of in some Universities with a good View, and for whetting the Understanding; yet they have given occasion to many to cavil about the most weighty Truths; insomuch, that you shall often hear them in publick Disputes, arguing with as little Respect and Humility about the *Being of a God*, as concerning the vainest and most frivolous *Entia Rationis*, or Chymera's of the

Brain; and you shall see them indifferently maintaining a *Thefts* of the *Great God of Heaven and Earth*, and immediately after discoursing of a *Vacuum*, or of *imaginary Space*; and without any distinction of Reverence in the one Case or in the other. This insensibly engages them in a sad Custom of vainly using the tremendous Name of GOD very frequently, and without the least Devotion, and of making that most supreme and adorable Being, which ought not to be thought of, much less named without Emotion, the Object of their wanton Speculations. What Evils this has been the occasion of in some, is very obvious to those who have experimented how much that Natural Contempt, which they feel in their Hearts (without Reason indeed) for Divine Things, has been thereby increased.

I leave it to those Gentlemen to whom the Superintendency over the Universities is intrusted, to find out Means, according to their great Wisdom, for obviating these Abuses; only, humbly offering it to their Consideration, whether the Weight of this great Affair, does not loudly call for an Answer to the following Questions: *First*, Whether it should not be forbid henceforwards, that the Name and Attributes of the most *adorable Deity*, should be made use of only as Means for exercising young Understandings, and furnishing Matters for Dispute, with which *Philosophy* does, besides this, sufficiently abound. *Secondly*, That those Truths, concerning GOD and his Perfections, in the *Metaphysics* and *Doctrine of Spirits*, wherewith Youth are to be instructed, be not any longer handled in Publick Disputations, but in Private Assemblies only, and (as it is the Custom in *Divinity*) after having poured out a Prayer to GOD, with that becoming Humility and Reverence which is due to the Great LORD of all Things;

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Things; the rather, because most commonly young People only (who are of an Age in which the Judgments are most easily byassed or corrupted, and the Passions do most prevail) are the Hearers of these Lectures and Disputations. By such Means we might begin to hope, that the Danger which arises from this disrespectful manner of Disputing, may be hinder'd from taking Root in young Minds; and that every body might be convinced by the pious Examples of the Academical Teachers, and reverend handling of these Matters, that Learned Men do likewise fear G O D; the contrary to which is maintain'd by many *Atheists*, and is one Method whereby they stifle the Remorses of their own Conscience.

SECT. XXV. *The Fifth Inducement, Inattention or Heedlessness.*

BESIDES what has been already said, there is still something more, which indeed does not carry Men into compleat *Atheism*, and yet does very much contribute to hinder them from discovering G O D in his Works; insomuch, that many People do, upon that Account, pass their Lives without observing, at least without being convinced, of these weighty Matters; and that is a *Natural Sloth and Carelessness, or want of considering, with proper Attention, those Things in which the Perfections of the Creator shine out so brightly.* We are all desirous to satisfy our Curiosity, and therefore we earnestly contemplate, and oftentimes enquire into the Causes of all those things which we take for Wonders; because the Manner in which they happen is unknown to us. If Comets or *Parbelia* appear, if the Sun or Moon happen to be eclipsed, how eagerly are they observed both by Learned and

Unlearned Men ; and yet we daily see the Sun rise, and the Moon and Stars shewing themselves; the Earth and Trees cover'd with Flowers and Fruits; Humane Creatures and Beasts procreating, and a thousand other Wonders, and remain very indifferent towards them all, without dwelling long enough upon the same, and observing them with that Care and Judgment we ought, or turning our Thoughts towards the first Cause and Author of all.

Methinks one might conclude, that the frequently repeated View of such Things, each of which alone are wonderful in themselves, should make so much the stronger Impression upon our Minds; and yet most commonly we experience the contrary. That this should obtain in ignorant People, is not so strange; but it is much to be lamented, that such a *Heedlessness* should many times be found in those, who do not want for good Understanding, and who are desirous to pass for Philosophers. One might likewise allow it in such as are not much accustomed to value or shew any Respect for the Knowledge of a God, or the true Cause of all Things; but that others should be so careless in this matter, who are so well convinced of the Importance of this Enquiry, that it does not suffer them to be silent, but upon the least Occasion do continually argue for it, (insomuch that I have not been able to discover the Doubts in which they were, or had been) is a thing that must needs appear unaccountable to every body.

The Reader will not dispute the Truth of what I have here advanced, when I tell him, that I have been personally acquainted with some Men, who were formerly thus heedless, and altogether insensible of the Works of the Great Creator; but being afterwards brought to a more due Attention,

tion, were astonish'd at themselves, that those very Things which a Wise Maker and Powerful Ruler did, as it were, cause them to feel with their Hands, which had been known to them so long before, which they had frequently meditated upon in their Studies, which they had read in the Works of other Men, and had often discours'd of them with others; should not have carried their Thoughts up to a God, nor caus'd them to feel in themselves the least Conviction of his Being.

If Custom be the occasion thereof, which, because we daily see so many Wonders, makes us receive them without any Impression; one can only say, that it is by such a Custom we become quite Blind, and wholly Insensible.

SECT. XXVI. *Means to prevent such Inattention.*

THE only Natural Means that I ever found effectual to render us more attentive to every Thing, is frequently to apply our selves to new Discoveries and Experiments, which appearing to us upon every Essay, to be New and Uncommon, do give us an occasion of observing with Astonishment the *Wisdom, Power and Goodness* of Him that orders all Things after such a manner; especially, if we endeavour to wean our selves (which is here absolutely necessary) from this our natural Sloth, and continually join our Experiments, with these Observations.

This is not the Place to take notice of another and true Cause of our Blindness, which, in this respect, is so great as to hinder us from seeing the Perfections of God in the Works of the Creation, tho' they be daily before our Eyes; to wit, *the universal Corruption of Mankind*; because this is only to be remedied by Prayers, and by the
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Grace of GOD itself, but no ways by natural Means, which is what we are here chiefly concerned about.

SECT. XXVII. *Why we only make use of Proofs drawn from Natural Philosophy.*

FROM all that has been already said, it may be inferr'd, that the exact and experimental Observations of what we see in the World, is a demonstrative Means, not only to obviate so many Causes and Inducements to *Atheism*, but likewise to attain to the Knowledge of a GOD and his Perfections by his Works: and let no Man think it strange, that in the following Discourses I make use of this Method, and not of other kind of Arguments, which are commonly called *Metaphysical*.

The Reasons that led me thereto are these:

First, Because many learned Persons have unanswerably confuted the *Atheists* after a *Metaphysical* Manner; that is, such a one as is built upon Reasoning: The Proofs therefore, of this Kind, may be found in great abundance in their Writings.

Secondly, Because Experience and Conversation with some of these unhappy Philosophers, has taught me, that the Contemplations of GOD's Works, when one could bring 'em thereto, has induced some among them to alter their Sentiments, who for many Years had withstood other Proofs; because the Subtleness of their Understanding seemed to furnish them always with a Handle to dispute against *Metaphysical* Arguments, and so left them still dissatisfied.

Finally, This Method will be allowed to be convincing, if not by finish'd *Atheists*, yet at least by unsettled and wavering Minds, who are not

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not arrived at that Perfection of Wickedness, as to deny the Divinity of the Holy Scriptures; because GOD himself has not thought fit to make use in his Word of artfully invented Philosophical Argumentations, and such as required more refin'd Judgments to understand, in order to prove his adorable Attributes; but does for the most part convince Men by his Works after this plain and simple manner, which is obvious to all, thus manifesting his Love and Mercy to us; since that notwithstanding the acutest Philosophers are forced to confess in many Events, that they have advanced but a very little Way in the Knowledge of his wonderful Works, and shall never be able to fathom many of them; yet they are so adapted to every body's, and even to the weakest Minds, that we need only open, and lift up our Eyes, to be irrefragably convinced that there is a wise Maker and Ruler of all Things, without any farther Help of Humane Wisdom or Philosophy.

SECT. XXVIII. *Because GOD is pleased to make use of this Way in his Holy Word.*

THE Word of GOD does likewise give Testimony to this same Method in many Places of it. Thus we see St. Paul makes use of the Creatures for a Demonstration of GOD's Eternal Existence; Rom. i. 20. *The invisible Things of him, from the Creation of the World, are clearly seen, being understood by the Things that are made, even his Eternal Power and Godhead.*

In the same manner David relating the Works of GOD in a most sublime and pathetic Strain, in several Verses of the 104th Psalm, proves from thence his great Wisdom, ver. 24. *O Lord, how manifold*

manifest are thy Works ! in Wisdom hast thou made them all.

Thus the G O D of Heaven does not command us to seek for Arguments from the Depths of Philosophy, in order to see his Power, but only to turn our Eyes towards his Works : *Isaiah xl. 26. Lift up your Eyes on high, and behold who hath created these Things that bringeth out their Host by Number ; he calleth them all by Names, by the Greatness of his Might, for that he is strong in Power not one faileth.*

His Mercies are also shewn from his Actions in the 107th *Psal.* We likewise see the Almighty himself in the Book of *Job*, Chap. xxxviii, xxxix, xl, & xli. making use of Proofs taken only from his Works ; exhorting us, in many Places of his Holy Word, after the most earnest Manner, thus to contemplate his Perfections in his Works. Thus we hear the Holy Ghost in the 107th *Psal.* ver 43. after having given a circumstantial Relation of the Actions of G O D, finally making this Conclusion : *Who is wise and will observe those things ? Even they shall understand the Loving-kindness of the Lord.*

From whence it plainly appears, that towards such wise understanding, no feigned Hypotheses, but an Observation of Things themselves, which can only be made by Experiments, is required ; for which Reason Men are wont even to this Time to bestow the *Latin* Term of *Observations* upon what we find out by Experience.

And so great a Stress is laid upon this Exhortation of knowing G O D by his Works, that those who do not study them after that Manner, are pronounced Foolish, and void of Understanding ; *Psal. xcij. 5, 6. O Lord how great are thy Works ? and thy Thoughts are very deep : a brutish Man knoweth not, neither doth a Fool understand this ; for which Reason,*

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Reason, the not enquiring into the same, is by the Spirit of God reckon'd among the Causes of *Atheism*; Psal. x. 4. *The Wicked, thro' the Pride of his Countenance, will not seek after God: God is not in all his Thoughts.*

SECT. XXIX. *The General Proof or Demonstration of a G O D.*

AFTER having fully comprehended all the foregoing, we might now have proceeded to the Contemplations of the World, and the Perfections of God, in the Composition, Parts and Motions thereof, were it not that what follows may yet seem to require, that we should previously shew after what Manner, from the visible World, and that which we see pass therein, a Proof may be formed upon which we may rely and be assured, *First*, That there is a God, that is to say, a Wise, Powerful and Gracious Maker and Director of all Things; And, *Secondly*, That the Bible (his revealed Word) is of a Supernatural and Divine Origin.

As to the Manner of demonstrating the First, I shall, without entering into deep Speculations, like some Philosophers, seriously entreat every one, that with a composed Mind, and divesting himself of his Passions and Prejudices, he would silently set down, and seriously consider, *First*, in case he should see that,

1. Not one, but a great many,
2. And various or different
3. Things entirely ignorant, or unknowing of all, and even of themselves too:
4. Each of them frequently after a particular Manner,
5. However always unchangeably, and observing the same Rule;

6. Do

6. Do act and move not once, but upon many Occasions and Times;

7. And not one of all them able to impart such *Motion* to itself;

8. Nor unless they thus come together of themselves, can produce one single Effect without their own Knowledge:

9. In the Production of which Effect or Thing, if some few Circumstances only, or oftentimes but one single one were wanting, it could not either be produced at all, or at least not in its due Perfection;

10. Altho' that same Effect should in itself be of great Use and Service, and sometimes of the utmost Importance:

Could he imagine otherwise, than that all these things are formed to that End, and brought together with that Design, to work such an Effect as we observe to be produced by them?

And, *Secondly*,

Supposing this first to be true, since these things are in themselves ignorant and unknowing of all that passes; whether every body must not agree, that they are all produced, and made to concur by a wise and understanding Agent, who had such an End and Design in his View? And whether any one can persuade himself that meer Chance, and unknowing Laws of Nature, or other Causes ignorantly co-operating, could have Place herein, and could have directed and governed these things in all their Circumstances and Motions for such a Purpose?

That this may be shewn after a more plain and not less certain manner, let us apply to some particular thing what has been just now advanced in general, and as it were in an abstracted manner; and let us suppose that in the middle of a sandy Down, or in a desert and solitary Place, where few

few People are used to pass, any one should find a Watch, shewing the Hours, Minutes, and Days of the Months; and having examined the same, should perceive so many different Wheels, nicely adapted by their Teeth to each other, and that one of them could not move without moving the rest of the whole Machine; and should farther observe, that those Wheels are made of *Brass*, in order to keep them from Rust; that the Spring is of *Steel*, no other Metal being so proper for that Purpose; that over the Hand there is placed a clear Glass; in the Space of which, if there were any other but a transparent Matter, he must be at the Pains of opening it every time to look upon the Hand: Besides all which, he might discover in it a Hole, and exactly opposite thereto a little square Pin: He would likewise see hanging to this same Watch a little Key composed of two Pieces, making a right Angle together; at the End of each of which there was a square Hole so order'd, that one of them was exactly adapted to the little Pin in the said Hole; which being applied thereto, a Chain would be wound up, and a Spring bent, by which means the Machine would be continued in Motion, which otherwise would be in an entire Rest: He might also find, that the other square Cavity, at the End of the little Key, was adapted to another Pin or Instrument, which being turned this way or that, makes the Hand move faster or slower. At the other End of this little Key there would be a flat Handle, which being moveable therein, might give him the Conveniency, that in the winding it up he should not be obliged to take hold of it at every Turn of his Fingers.

Lastly, He would perceive, that if there were any Defect either in the Wheels, Spring, or any other Parts of the Watch; or if they had been
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put together after any other Manner, the whole Watch would have been entirely useless.

Now the Question is, in order to form a kind of Demonstration from hence, *First*, Whether any Body can imagine, that such a Watch among other Purposes, to which it might perhaps be serviceable, was not likewise made for this End, that it should shew the Hours, Minutes, and Day of the Month. *Secondly*, Whether he should make the least Scruple to admit it for a Truth, that such a Machine was made and put together by an understanding Artificer for this very Purpose, who when he made it himself, knew that, and to what End he had made it.

And *Thirdly*, Whether it be possible that he can persuade himself that this Watch, with all belonging to it, the Niceness of its Make, Figure of so many Parts, and other Contrivances for shewing the Time, could have acquired its Being and Form by meer Chance only, which operated indifferently one way or another, and without any certain Rule or Direction?

Or otherwise, whether he could expect to pass for a Man of Sense and Understanding, if having found this Watch in a solitary Place, he should pretend to believe that it was not made by a skilful Workman, nor that its Parts were put together with Judgment; but that there was a certain ignorant, and yet necessary Law of Nature prevailing in the World, that had brought into a regular Method all the Parts, of which this Watch consisted, and had adapted each of them to the Use of shewing the Time of the Day; and especially that such a Law of Nature was not only ignorant and unsensible of all that it did, or brought to pass, but likewise, that no Being, endued with any Wisdom or Understanding, had established and produced this Law at the Beginning, or in the least contributed

buted to the making the several Parts that composed a Machine proper to shew the Hours.

Once again, I beseech every one who thinks that he is at all concerned to know whether there be a God; that he would in his Retirement seriously ask himself these Questions; and consider how a Man, divested of Passion and Prejudice, would and ought to answer them.

We have dwelt the longer upon this Subject, because, when the Reader shall observe us to speak, in the following Treatise, of *Occult Causes, Unintelligible Fatality, Ignorant Laws of Nature, &c.* he may always bear in mind, that we thereby mean such as we have been describing, namely, what have no kind of Knowledge in themselves (which every one will readily allow) but likewise such as have acquired their Original, and discharge all their Functions and Operations, without any wise Direction; which, as we have shewn before, is the principal Difference between an unhappy Atheist, and those who Own, Love, and Fear a God, that he has not only created all things according to his Pleasure, but does with the same Pleasure and Freedom preserve and govern them.

What has been said above, concerning a *Watch*, is not less applicable to all other artificial Works: It will be therefore unnecessary to alledge any farther Examples of *Mills, Ships, Sluices, Houses, Paintings, &c.* In all which, the Wisdom and Understanding of the Maker does equally appear.

Now that our Consent may not be suspended by these Evasions, namely, that these are no Mathematical Proofs (for besides that it would be easy to trace the external Manner of a Mathematical Demonstration herein; let any Mathematician, not excepting the very best, seriously reflect upon the Structure of a Clock, upon the

Frame of the *Stadt-houfe* at *Amsterdam*, or thousand other Artificial Works; and if he do well and thoroughly comprehend the Relation which all the Parts bear to each other, and the Service they thereby render to Mankind, and at the same time considers that nothing of that whereof they are composed, is endow'd with the least Knowledge or Judgment) let such a Man, I say, sincerely declare, whether he be not as fully and strongly convinced, that they are not made or produced by *Meer Chance*, or *Ignorant Causes*, but by *Skilful Workmen, Architects, and Engineers*, as he is of any Proposition in *Euclid*. Yea, in case he were obliged to stake his Life against the said *Stadt-houfe*, or the Value thereof (between which there is otherwise no comparison) and to say which was truest, that this *Stadt-houfe* was built by *Chance*, and had acquired all its Parts and Proportions without any wise Direction; or that it was made by an *able Architect*, with a view of becoming useful to Mankind; would he make any Scruple, think you, to declare for the latter?

Finally, We may apply all that has been said above to demonstrate, that there is such a Wise, Mighty, and Merciful Being as God, in case we can make appear with as great (not to say a much greater) Certainty and Conviction, from the Construction of the visible World, and all that passes therein, that there is a God and Great Creator, who in Wisdom has made them all; as we can shew from the Structure of a Watch, and the Uses that result from the same, that it has been made and put together by a judicious and skilful Workman; and this we doubt not of doing in the following Contemplations, with all necessary Clearness.

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SECT. XXX. *A particular Manner of Corroborating these Proofs in some other Circumstances.*

We shall not here enumerate other Kinds of Proofs, to shew the Defect of the Principles of these miserable Cavillers, which we have made use of upon some particular Occasions in this following Work, because we will not make this *Preface* too long. They that find them in some Places are desired to apply them to others, where they think them to be of equal Force; tho', for Brevity sake, we may have there omitted them.

As for Instance, in case the Reader be not sufficiently affected or convinced by what is said of Living Creatures, Plants, Heavenly Bodies, and such like, let him imagine to himself that he saw the same things imitated in little; and that tho' they be incomparably more imperfect, yet they do in some manner counterfeit the Works of Nature. To speak more plainly, let him fancy that he sees a Wooden Horse put into a Motion by Springs and Wheels, a Wooden Bird flying (of which History has made mention;) or let him suppose that he sees in a little Machine, a gilded Globe, representing the Sun, and other little Balls, which like Planets circulate about it; and then let him ask himself, whether he has Boldness enough to maintain, in the Presence of Wise and Learned Men, that all these Things appear to him to be produced by *meer Chance*, or by certain *unknowing natural Laws*? And whether he has not a great deal of Reason to believe, that such Sentiments would be justly laughed at, even by the Ignorant themselves? And after all, let him consider with how much less Reason he entertains such Opinions, entirely different from those of all
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wise Men, concerning the true, natural, and unconceivably more perfect Things, which daily occur to his own, and all other Mens Observations in the World.

I have not urged this Matter in every Part of the following Sheets, where perhaps it might have been equally useful, because I would not swell the Work too much, which will otherwise be large enough ; but I have nevertheless thought it my Duty to add this here, and to suggest this Advice to an Atheist who shall take the Pains of Reading what I have writ, or will otherwise seriously contemplate the *Structure* of the *World*, since I have often found it of Use, and a proper Means to bring those, who were otherwise sufficiently addicted to Cavilling, to a kind of Retrogradation, and to silence them for a Time.

SECT. XXXI. *A General Proof, that the Scriptures are of a Divine Original.*

THE second Thing that is here necessary to be enquired into, before we pass on to the *Contemplations of the World*, is a certain Manner of proving (which we shall upon some Occasions hereafter insist on) that the *Bible*, as it is call'd by *Christians*, was writ by a certain Great and more than Humane Wisdom, and that it is of Divine Authority and Original.

To speak a Word or two of it here in general, I entreat my Reader seriously and carefully to consider ;

In case he should meet with a Book, which for weighty Reasons was held to be Divine by other People, among whom there were a great many that he allowed to be very understanding Persons;
and

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and supposing, that whilst he read and examined it, he should find,

First, That this Book did frequently make mention of certain Qualities of Natural Things (tho' with another View, and as it were *en passant*) after such a Manner, as none but an Eminent, Wise, and Experienced Naturalist could do; whether he would not be obliged to conclude, with respect to that only, that such a Book must have been writ with singular Wisdom?

Secondly, Suppose he should be farther convinc'd, by irrefragable Proofs, that this Book did represent, with the clearest Words, certain Properties of Natural Things, which at the same Time it was writ (at least so far as can appear to us) were not known to any living Person, nor for want of the necessary Instruments, could possibly be known to any, whether it were to be doubted, that such a Book were writ with more than Humane Wisdom?

And this being granted; from whom can we more reasonably conceive it to be derived, than from the Omniscient Creator of all Things, to whom alone the things that were hid from every one else in those Ages, were known and open?

And in case you desire to have this last proved more strongly, we may subjoin, *Thirdly*, That in some Places of this Book is express mention made of the Bounds and Limits of Humane Knowledge in future things; the Truth of which could not appear, but to the following Generations.

This being so, as it shall be proved hereafter, Can any but a Divine Power determine and limit,

by clear and plain Expressions, that certain things shall come to pass after many Ages? And when they have so happened, must not every one acknowledge, that it could proceed from no other than a Divine Original?

SECT. XXXII. *No Proofs can be brought of the Divinity of the Alcoran of the Mahometans.*

WHAT has been here said concerning the wonderful Wisdom, that so brightly appears in the Holy Scriptures, might truly be urged upon many Occasions against the *Alcoran* of the *Mahometans*, where we should in vain seek for an Account of the Construction of the World, of which so much appears in the Bible of the *Christians*: but since these Papers are not so much calculated for the Conviction of *Mahometans* as of *Atheists* and *Unbelievers* in general, it seems to me sufficient, just to touch upon it here, without repeating it upon every Occasion in the following Discourses.

SECT. XXXIII. *A short Account of what is proposed to be done in the following Work.*

Now that we may reduce all that has been said to it's *End* and *Design*, and that we may convince every reasonable Person of the Perfections of GOD, this alone chiefly remains;

First, That we endeavour to shew, that in the visible World, or rather in that little of it that is as yet thorowly known to us by Experience, there does appear so much Wisdom, so much Power, so much Goodness and wonderful Views, that
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the greatest Work of Art that ever was prepared by Men, is not comparable to it in the least.

And, *Secondly*, that we endeavour, by convincing Examples, to show the undeniable Truth of what has been said above, relating to the Holy Scriptures.

We know very well that an *Atheist* may, upon some Occasions, object against this last; that, *perhaps*, at the Time when the Bible was writ, *Telescopes* and *Microscopes* were in use, and, *possibly*, brought to as great, if not greater Perfection than we find them in this present Age; by which Means they will endeavour to evade the Proof which we, in some Places, have urged from the late Discoveries thereof: But to answer them in one Word, let them consider with themselves,

First, That altho' we have Astronomical Observations of many Ages past, and with them the Descriptions of several Instruments then used; yet we do not find any mention made of *Telescopes*, nor so much as the Name of *Microscopes* among any of the ancient Enquirers into Nature.

Secondly, That the Inventers of these two Instruments, who lived in the foregoing Age, were known to all the Philosophers; no body being yet able to prove from any Memorials, that they were known to others before.

Thirdly, Whether it be credible, that the old *Astronomers* or *Naturalists*, if they had known the Things that have been since discover'd by these *Optical* Instruments, would have transmitted down

to Posterity, their defective, and, many times, false Conceptions of Things.

Finally, And which is of the greatest Importance, let them seriously consider, how prudent it is, in a Matter upon which their everlasting Welfare or Misery depends, to support their Sentiments with a *perhaps, or it may be*, when, besides, every Thing that appears in History makes against 'em.



The



The Religious Philosopher:

OR, THE
Right Use of the Contemplation

OF THE
WORLD,

FOR THE
Conviction of Atheists and Infidels.

CONTEMPLATION I.

Of the Vanity of all Worldly Things.

SECT. I. *Every Man is placed here without his own
Concurrence.*

TO begin therefore, by convincing not only those who are still under Doubts, (whether they be to be reckoned among the External Christians or not) but even the deplorable and obstinate *Atheist*, of the great Necessity there is to be rightly assured of the most important Truths, and to correct those Mistakes which he has hitherto

hitherto admitted concerning every one of 'em; he is entreated most seriously to reflect upon the Things which his own Experience informs him daily come to pass about him, and to ask his own Conscience, whether he don't find himself placed in this World without any A& or Concurrency on his own Part? Whether it be in his Power to prevent his being one while Happy, Healthy and Strong; another while Unhappy, Sick and in Pain? Whether one Day does not follow another without his Leave, in which divers things befall him, some with, others against his Mind, notwithstanding that he feels in himself a continual Desire influencing and governing all his Endeavours of obtaining Good, and avoiding Evil; which sometimes succeeds, and at other times happens quite otherwise than he hoped for or intended, by Accidents which he could not escape?

Whether he does not observe, that what befalls him is in common with other Men? But chiefly, Whether he does not see that many Men die daily, and that very few of them seem to have any Thoughts concerning Death, especially whilst they are in Health? Notwithstanding that Sicknesses and Diseases, by which they are snatched away, oftentimes stand in need of but few Weeks, sometimes few Days, yea even Hours, to change them from strong and healthy Men into dead Bodies or Carcasses.

SECT. II. And must be convinced of the Uncertainty of his Life.

FURTHER, whether he is not like all other Men, ignorant of the Time when Death shall overtake him? Yea, at the End of one Year he sees a great many, who, in the Beginning of the same, were alive and healthy (and some of whom seemed

to

to be stronger than himself) to be singled, as it were with Design, out of the great Number of Mankind, and to be a Sacrifice to Death and the Grave; and that no body has been able hitherto to find out any Rule or Law whereby he could conclude, that this or that Man should die first; unless perhaps some very old or incurable Persons, of whom indeed he might say, that their Death was not far off: But even in such case, 'tis not less true that he is ignorant, as near as they may seem to be to their End, whether he himself shall not go before them: so that every Man is forced to own, that his End may be near, as well as that of those whom he sees die before him; and who, whilst they were in Health, knew as little thereof, as he himself does now of his own Death.

SECT. III. *He must likewise be convinced of the Vanity of all worldly Things with respect to himself.*

NOW since Death does so surely overtake every Man, and yet the Time of it is so uncertain; since it deprives us of the Use and Enjoyment of all that is in the World; ought not every one that considers these Matters be convinced of the great Vanity that is in himself, and in all worldly Things with respect to him? Forasmuch as he cannot enjoy either Profit or Pleasure from thence, but so long as he lives, and how long, or how short that Life will last, he knows not. This only he knows, that when he is arrived to a certain Number of Years, it cannot be very long: And he cannot say, if he considers every thing as he ought, that it is very desirable to attain to a great Age; since being deprived of the Use of all his Faculties, his Death is as it were anticipated thereby; for it leaves him neither Feet to walk, Eyes to see, Ears to hear, or Teeth to eat with;
and

and thus, while he is still alive, he is by degrees thrust out of the Company of Men, and becomes, as one may say, a living Carcass.

SECT. IV. *It is not even desirable to live here continually, tho' in Health.*

NOW if we should add to all this, that such as live long are not only subject to the Infirmities of old Age, but often to very grievous Sickness and Pains; some of which are entirely or almost incurable, viz. in case he be deprived of all his Strength, and worn away by a Consumption, or tormented by the Gout, or Stone in the Bladder, by a cancerous Humour, or by the Falling-Sickness; to say nothing of a thousand other Distempers, to which he is obnoxious, and which he may justly apprehend, because he sees so many other Men affected with 'em; would not he have a great deal of Reason to wish that merciful Death might set him free from all these, and from miserable old Age at the same time?

Now if one should suppose, which however scarce happens to any Man, that the Evils of old Age do not render his Life a Burden, and that he shall enjoy even as long as the World itself shall last, the same Strength both of Body and Mind as he did in his Youth; yet when he seriously considers every thing, this very State and Condition, far from being desirable, must appear to him very deplorable: For, *First*, in case his Native Country should be ruined and laid waste by Earthquakes, Inundations, or War, he cannot escape Misery and Poverty as well as the rest: And how many Years of tedious Labour are there required to repair what he has lost, so as to be able to enjoy the same the remaining Part of his Life? And having scraped it up again with Trouble,

ble, must not this Man, who is to live as long as the World stands, be always in Pain and Fear of losing it, either after the same, or some other manner? At least since the World itself is subject to those Revolutions with which the Histories of all Ages have acquainted us. How few Governments are there that have been able to keep their Footing for several Ages together, and of which the Inhabitants have not been driven or rooted out? And on the contrary, how many can we reckon, which after they have risen to the highest Degree of Glory and Grandeur, yet at last have found their End in an entire Destruction? So that even such a long and healthy Life, as we have been supposing, would only be a miserable Pilgrimage for him, in which, when he had hardly come out of one calamitous State, he would be in a continual Apprehension of another.

And if no evil Accident should overtake him (which is not to be conceived) what Pleasures are there in the World that are lasting? So that he can expect nothing else but that such a Pleasure, which whilst it was new, was very agreeable to him, either by long Enjoyment (as Custom renders all things) would become first indifferent, and afterwards insipid; or at best, by the Uncertainty which is visible in all things, would soon forsake him: Had he a Wife, Children, and good Friends, which are the most comfortable things of this World, they would all die before him; and he would every time be subject to that Heart-breaking Sorrow of losing those dearest Treasures were they to live long? So soon as they are overtaken by the Infirmities of old Age, they would only be continual Objects of Pity, and consequently of Grief to him: Yea, every Thirty, Forty, or at least Fifty Years, he would meet with
a new

a new, and consequently a strange Generation, and be obliged at every Turn to enter into new Friendships and a new Acquaintance; or to converse with unknown People, whose Inclinations he must study and learn to know again, to the End that he may, whether he will or no, conform his own to theirs, if he expects to enjoy any Favour or Kindness among them, and not to be excluded from their Conversation as a stiff and ill-natur'd Fellow: And if he has had Children, of which even a numerous Posterity are remaining, what Friendship and Love can he promise himself from them? Who, tho' they were descended from him, would be yet in a remote Degree of Relation; since Experience teaches us, how soon all Kindred, after a few Descents, grow strange to one another: And I have often thought, if *Adam* himself, our common Father, should return again to the World, and stay here some Ages, whether any of his Posterity would receive him friendly? Especially if he should pretend to make use of that Right, by which he alone would be entitled to, the Property and Government of every thing: Would not the most Part, if not every individual Man, think that he did them Wrong, and see him, with concern, taking Possession of their Habitations? Now in case the Respect and Love which every one owes him, could not so far prevail, as to render a Father happy among his Posterity, what could be expected by a Man in so great, tho' strong and healthy old Age, who would be no longer considered as a Father, but as a remote Kinsman, whose Pedigree could not be traced, or perhaps even as a meer Stranger?

SECT. V. *The miserable Condition of the Atheists.*

SINCE then a long and healthful Life, which otherwise seems to be the most desirable Blessing upon Earth, is so vain, a Man cannot be render'd happy thereby; let any one who doubts or denies the Perfections of a GOD, extend his Thoughts farther; and see, *First*, how dreadful such a Life would be to him in particular, even tho', according to his miserable Philosophy, he had no GOD to fear, and that all Things were directed either by meer Chance, or by irrational, unknowing, and necessary Causes.

For from such Principles as these he must grant, that in case he were unhappy, nothing but Chance could relieve him; if he were happy, since the Cause thereof is accidental and ignorant of its own Effects, he must live in a continual Fear, that every Moment may change his Condition: And not to reckon up all the Circumstances that may evince the same, what is there in the World from which he can expect the least Happiness or Advantage with any Foundation of a reasonable Hope, and from whence he can expect any Love or Good-will towards him, let him behave himself as he will? And that Man's Life must be very miserable, who is neither Loved nor Esteemed by any body: Suppose he were a Prince that governs a whole Nation, how can he think, without great Uneasiness, that it is by meer Chance his Subjects obey him? If he be a Subject, and lives under the Command of a Superior; must he not tremble when he considers that it is accidental only that his Goods are not stoln; his Houses burnt; his Wife and Daughters ravished; his Sons carried into Slavery, or murdered; and that it is by meer Accident that

his

his Children, being Wicked, do not, without any Scruple of Conscience, Poison him for the sake of his Inheritance; in case they think he keeps them too long out of it? And since upon this same Hypothesis there is no kind of Order or Providence, and that Chance, as Chance, may at all times produce, indifferently, this or that Effect; must he not tremble when he looks upon the Earth, which, if every thing depends upon Chance, may immediately begin to burn under him, or may open her Mouth and swallow him up? And, if he looks into the Air, must he not imagine, that it is purely Accidental that he is not destroyed by Storms and Tempests, by Thunder and Lightning, or that Rains and unseasonable Weather do not ruin all his Plantations and Possessions?

In vain, also, will he endeavour with such like Conceits to avoid all these Terrors; tho' he should admit that it was not a meer Chance, but an unintelligent Necessity which governs the Universe by certain unchangeable Laws; for since according to these supposed Laws, he sees several interfering Operations of Nature come to pass, whilst he sees the Air one time Calm, another time Tempestuous; whilst he sees the Wind from the South, and then again from the North; the Sea Ebbing and Flowing; one Season extremely Hot, another very Cold, and the like; must he not confess (tho' he should suppose that all this did necessarily happen) that it will be as terrible to him as Chance itself; to him who knows not when a contrary Effect shall be produced according to these same Laws.

SECT. VI. *The Advantages which they that Love and Fear a God enjoy.*

LASTLY, let him tell us sincerely, whethre in respect to all that has been said, he does not think those Persons to be unspeakably more happy, who are convinced that they depend upon an adorable Creator ; by whose Wisdom they have been so wonderfully formed ; whose Power has render'd so many of his Creatures subservient to their own Well-being ; who has given them the Capacity to enjoy the same with Pleasure and Thankfulness ; who being Wise and Mighty can preserve them, and being Merciful will preserve them ; that without his good Pleasure, none of the aforesaid Evils come upon them ; inasmuch, that if He be with them, nothing can be against them ; who, besides the good Things of Nature which He is largely and constantly dealing out to them, makes known his Word to them ; and to remove all their Doubts, has stamp'd it with irrefragable Marks of its Divine Original ; who has there revealed his Will, pursuant to which He will be sought after, served, thanked, and praised by them ; who has there manifested his Love to them, which passes all Understanding ; and has likewise promised to render them eternally happy after Death.

SECT. VII. *It is therefore necessary to seek for the Demonstrations of a God, Psalm xiv. 1.*

NOW since every Atheist must confess, that his own Principles (unless he will deny them too) do render him unhappy, and cause him to live in continual Apprehensions ; I leave him to judge, whether a Man must not be a very absurd Person

and, as it were, an Enemy to himself; who notwithstanding that he sees the contrary Opinion maintain'd by many others, of whose Wisdom he has no Reason to doubt, yet takes all the Pains imaginable to perswade himself that there is no GOD; and therefore, whether the *Holy Penman* of the first Verse of the 14th *Psalms*, has not a great deal of Reason to give such a Man the Name of *Fool*, who tho' he can never prove his Opinions, yet with all his Heart, and all his Soul, endeavours to make himself miserable, and to run headlong into a State full of Terror and Distraction; that is to say, into the Condition of an *Atheist*?

For a Confirmation of the Truth of what has been here said, I could farther add, that I myself have heard one of these miserable Wretches, whose Judgment seem'd capable of every thing but acknowledging a GOD, lament the Unhappiness of his Condition with great frankness, and in the most pathetick manner.

And I can't forbear saying, that the Remembrance of it does still very much affect me whilst I am now writing it, tho' long after his Decease.

To proceed; If any one has a true Love for himself, and does but hear that it is maintained by many Persons for an uncontroverted Truth, that there is a *Wise, Mighty, and Merciful* Creator of the Universe, who can render all those that endeavour to know, serve, and honour Him, happy, both now and for ever; and those that deny or despise Him, miserable to all Eternity: I say, that Man must be in a very desperate Mind, if he does not think it to be of the utmost importance to enquire into the Force of such a Proof, upon which so many wise Men, living and dying, do entirely depend.

SECT. VIII. *The Transition to the following Contemplations.*

I HOPE then, that among these unhappy Men there may be some found, who, in order to free themselves from these sad Uncertainties (for no *Atheist* ever had any Certainty of his wretched Notions) will think it worth their Pains, seriously to weigh the Arguments that may contribute thereto; and we beseech such to pass on along with us to the following Contemplations; and perhaps the Great GOD of Heaven and Earth may vouchsafe (as we heartily beg of Him for their Sakes) to open their Eyes, to the End that they may see, and be fully convinced of the unexpressibly amiable Perfections of his Glorious Works.



CONTEMPLATION II.

Of all that is Visible, and of Ourselves in particular.

SECT. I. *It is necessary to call upon GOD at the Beginning.*

BEFORE we come to the Thing itself, and from the Visible Part of the World endeavour to shew, that in the Structure thereof, the Wisdom, Power and Goodness of the Great Creator shines out with more Brightness and Lustre, than to admit of a Comparison between any of his Works, and those of the most skilful Artificer

that ever was. Let it not seem strange to any one, that in this Enquiry, which perhaps may be thought purely natural, we affirm it to be absolutely necessary, first of all to implore the Great Creator and Governour of all Things, with the deepest Humility, that He would be pleased to enlighten our Understanding (which in itself is so dim) that we may view and comprehend the Beauties and Wonders of his Works; and farther, that thro' his Goodness He would vouchsafe to purify our Hearts from all contradicting Passions and unreasonable Notions resulting from thence; since it is not unknown to any one who has obtained this Grace, that he can, as it were, feel and discover, in innumerable Things, with an entire Conviction of his Conscience, the adorable Maker of them; that many things have often presented themselves to his Mind formerly, and have been rightly understood and comprehended by him, without once exciting him to look up to the first and chief Cause thereof: So that it plainly appears from hence, that neither the Penetration of his Judgment, nor the Things themselves, are sufficient to lead him to a right Contemplation, without some farther Assistance besides them. And in case an Atheist should only consider these Convictions as Historical Truths; yet at least he must acknowledge, that in a Matter of so great Importance, and upon which his everlasting Happiness or Misery depends; it would do him no Harm, according to his own Principles, if, like the *Athenians*, he should invoke the Assistance of a *G O D*, as yet *unknown* to him.

SECT. II. *GOD's Eternal Existence proved from the Creatures.*

Now to proceed to our intended Work : Since our Design is rather to offer or propose the Proofs of the Perfections of GOD, that is to say, of his *Wisdom, Power, and Goodness*, by way of Conviction to unhappy *Atheists*, and doubting Minds, than to prove his *Eternal Existence*, that being not denied by any *Atheists* who own an *Eternal Being*, as far as I know ; yet if there be any among them so blind as still to doubt, whether this also can be demonstrated from his Works, we shall likewise endeavour to give them full Satisfaction herein, and to produce unanswerable Proofs thereof in this very Place, before we proceed to the other.

Let the *Atheist* then ask himself, upon the Supposition that there was no Eternal Being, that is, in case there ever was a compleat *Nothing*, when there was neither Creator nor Creature, nor any thing whatever that had an Existence, whether he must not be convinced, that in all Eternity the smallest Thing whatever could not come to exist ; and that such a *Nothing* must remain and continue to infinite Ages a meer and simple *Nothing* ?

So that not only from these vastly extended Heavens, and their unspeakable great Lights and Bodies, but even from the most tender Leaf or Grass, from the most contemptible Stone we tread upon, and from the smallest Grain of Sand, this Assertion can be irrefragably maintained ; since if ever there was a compleat *Nothing*, the very meanest of all these could never have been produced, or made to exist in an Infinity of Ages.

SECT. III. *The same proved from Romans i. 20.*

AFTER the same manner we see the Apostle Paul proving God's *Eternal Power*, whereby He Exists of himself from all Ages, and his *Divinity*, whereby he is distinguished from all Creatures that have had a Beginning: And thus speaking in his Epistle to the *Romans*, Ch. i. v. 20. *The invisible Things of him from the Creation of the World are clearly seen, being understood by the Things that are made, even his Eternal Power and Godhead; so that they are without Excuse:* And shewing likewise that in naming the Creatures in general, he excepts nothing out of 'em, how small soever it may be, which by its Existence is not capable of convincing, with the utmost Certainty, every one that has not quite lost the Use of his Reason, of GOD's *Eternal Power and Divinity*, that is, among other Things, of his *Eternal Existence*.

SECT. IV. *The Contemplation of Ourselves in general.*

NOW as this Contemplation of all Creatures in general, after the aforesaid manner, is a Testimony to every Man's Conscience, that there is an Eternal GOD; so likewise will every Man that only views the Frame and Constitution of himself, (and considers who he is, and whereof he consists; how he is come into this World and preserv'd therein,) from thence be convinced of the Wisdom, Power, and Goodness of such a GOD, without hardly considering any other Particulars, tho' we hope also to account for them hereafter.

He, therefore, who has hitherto denied or doubted of so weighty a Truth, let him turn his Eyes and Thoughts first upon himself only, when

when he cannot but confess, that he has a Body, of which, being in Health, he is capable to move some Parts, such as the Hands, Feet, Eyes, &c. arbitrarily, and according to his own Pleasure; and again (which is very remarkable) that his Will has little or no Influence or Power over other Parts: Thus his Heart beats, his Blood circulates, his Stomach and Bowels are moved; the Humours and Fluids, which compose so great a Part of his Body, produce several Effects in him, without his being able either immediately to hinder or promote their Operation: Moreover, he finds that he Understands, Wills, Reasons, Loves, Hates, Fears, Hopes, and (in one Word, that Philosophers commonly make use of to Sum up the whole) that he *Thinks*.

SECT. V. *The Contemplation of our Body, which is Earth.*

Now upon enquiring first into our Body, we are convinced by certain Experience, that the same consists of the Food we use, such as Herbs, Fruits, Corn, Flesh, Fish, Water, and the like. The Beasts have likewise their Food; and tho' these eat one another, yet the Food of most of them consists of Plants and Water; for as for Fossils, Metals, and such like, we do not yet know that they serve for Food to any Creatures; and tho' they should, yet the following Proof will remain in its full Force.

Now all these Plants spring out of the Earth, and being sown, seem to draw their whole Substance from Earth and Water, excepting only what Air, Light, or such like Matter, may contribute thereto; which Mixture of all together, because we meet with it in all fruitful Soils, we shall hereafter, for brevity sake, call by the common Name of Earth. From

From whence then a Man must finally conclude, that the Matter whereof his Body consists, is nothing but the Water he uses in his Drink, together with an altered and disguised Earth, which first becomes Plants, and afterwards is turned into the Substance of his Body.

Now if all this does not appear clearly enough to him, let him suppose the Person of a Man, who having been before very fat and heavy, has lost some Pounds of Fat by Sickness; if such a Man being restored to his Health, and using no other Food than Bread and Water, should again attain to his first Weight; whence proceeds this his new Flesh, but from the aforesaid Bread and Water? but more especially, if he considers the Smallness of his Body in the very beginning, which when his Mother first conceived him, was scarce of the Weight of half an Ounce; tho' the same Body afterwards, first by the Nourishment it received from the Mother, and afterwards what it took in itself (both which, with respect to the Matter of it, can be called nothing but Earth) grows up to a Man of so many Pounds weight: And will he then still doubt, since all this Nourishment consists of Water and Earth only, whether his whole Body, in its utmost Extent, is any thing else but a metamorphosed or transubstantiated Earth?

SECT. VI. *That the Body does not Think.*

HAVING now discover'd these Things concerning his Body (that we may advance a little farther) let him suppose himself sitting with another Person at Dinner; could he think that the Bread, Flesh, Fish, Beer, Wine, &c. that are eaten and drunk, should first become Nourishment,

ment, and afterwards being turned into his Body (or rather, that a quantity of Earth, from whence this Nourishment proceeds) has the Capacity to judge of, and to understand his, or another Man's Discourse; or can comprehend the Demonstration of a Proposition in *Euclid*? or let him consider, whether a skilful Chymist and Philosopher could ever justly fancy to himself, that he was able to produce, out of such Food or Nourishment, a solid or fluid Body (besides which two, no third can be shewn) that can Think, Reason, and Discourse like a Man? Now I cannot bring myself to such a Belief, that there ever was any Man, who desired to pass for a Person of the least Sense, capable of advancing such Notions, and intrrenching himself in the same, against an approaching Eternity.

SECT. VII. *The Soul demonstrated.*

ALL this being duly weighed, can a Man make any other sort of Conclusion, than that his Food, consisting of Earth and Water, is the Substance of his Body; and that nothing of those, or of any thing else produced by those, (nor consequently his Body) is capable of *Understanding, Reasoning, or Thinking.*

And yet he is assured, and plainly convinced, that he both *Understands, Reasons, and Thinks*: This therefore is an irrefragable Proof that there is something else in him besides his Body, which *Understands, Reasons and Thinks*; so that he does thereby know so much of himself, as that he is composed of two distinct Substances, *viz.* of a Body which is Earth, and of some other thing besides his Body, which other thing *Understands, Reasons, and Thinks*: This last is called the *Soul*; and

and therefore he knows that he does consist of a *Body and Soul.*

SECT. VIII. *No Man proceeds from himself, nor from his Parents, but from another.*

BEING come thus far, and knowing what he is, let a *Sceptick*, or an *Atheist*, go a little farther with us, and endeavour to find out how he came into this World, and how he is here supported.

And that he may bring himself to consider the same experimentally, let him examine himself, and see, if it was in his Choice or Power to be here or not, whether he would choose to be formed Sick or Healthy, Blind or Seeing, Streight or Crooked: To all which, without doubt, he will answer, that he would rather be form'd with the good Qualities. On the contrary, let him by his own Experience enquire, whether he be not placed here without the least Act or Concurrence of himself, and entirely without his own Knowledge, in the Condition wherein he finds himself, and wholly incapable of bestowing on himself more or fewer Advantages of Nature: Consequently then, he must be convinced that he does not proceed from himself, but from another.

But supposing it should be objected by some body (who being wavering and full of Doubts, and unwilling to consent to what has been here advanced, least he should be forced to acknowledge a God) that his Parents were, by way of Procreation, the first Causes of his Existence in this World; which at first sight carries something specious with it: yet if he will be pleased to penetrate farther into the Matter, he cannot refuse believing, that his Parents, as well as others, owe their Beginning to that desire of propagating
their

their Species, which is naturally implanted in all Creatures; without any Certainty at the same time, or thought of the Consequences of such an Act. And must he not, moreover, confess, that none of 'em all were capable of knowing or saying whether it should be a Man or Woman, a deformed or well-shaped Child, that was to be produced? Yea, after the Birth, does it clearly appear to either of the Parents, how the Body of such a Child is framed with respect to its Veins, Nerves, Flesh, Bones, Humours, and other Parts?

Now if all this be brought to pass without the Knowledge of the Parents; if they be entirely ignorant of the Composition or Structure of their Child, how can he look upon them as the true Cause of his Being and Subsisting? Can one justly hold that Person for the Artificer, or the real Cause of any Machine, who is forced to own that he does not know any thing of the Construction, nor how it came to be so made? and yet more, who did not so much as know even whether it was made by him, tho' he did all that lay in his Power towards the Production of it?

And since he cannot judge that his Parents have contributed more to him than others do to their Children, must he not own that it follows from thence, that he is placed here entirely without his own Concurrence, and without being able to prove that his Parents are any thing else but unknowing, and consequently no true, but, at the most, instrumental Causes only of his Existence?

Moreover, to the end that we may obviate all Evasions, and demonstrate undeniably that he cannot be produced by his Parents as true Causes, let him recollect, that besides his Body there is a Soul of which he consists, which has been already shewn to be entirely different from his Body. Now all that could happen towards his
Pro

Production on the part of his Parents, seems only to have respect to his Body, and consists in nothing more than in the Communication of the *Semen Corporeum*, which likewise has its Original from Food and Nourishment; and therefore, according to what has been proved above, is nothing else but metamorphosed Earth and Water. Now this Earth and Water, or any thing else that proceeds from them, does neither Understand nor Think, and yet he himself does both; for which Reason he ought certainly to be convinced, that he, as a Man, that is to say, as an intelligent, rational, and thinking Creature, can by no means owe his Being to his Parents; and since he cannot be the Cause of himself neither, he must therefore, as well as all his Forefathers, have been brought into the World by some other Being.

I have here in the Beginning, that I might not seem to argue too acutely, passed over those modern Observations, by which it is pretended, that the Humane Body draws its Origin from a *Stamen* or Fundamental Principle, in which the Members are rolled up as in a Clew or Ball of Thread; which afterwards, by the help of Nourishment, is filled up and unfolded to a Visible Body. The Reason is, because the Proof which we have here in view, would still remain of the same Force. *First*, Since this *Stamen*, how small soever it may be, whilst it continues unfolded, is nevertheless a real Corporeal Substance. *Secondly*, Because it is not yet proved, that this *Stamen* does not proceed from the Fluids of the Father or Mother, or of both, and therefore does likewise consist of disguised Earth. *Thirdly*, By what Cause soever this *Stamen* is produced, it cannot be denied, that when it is quite unfolded into a Visible Body, it is nevertheless a Corporeal Sub-

Substance, and so remains. Now that such a Substance can *Discourse* or *Think*, no body that would pass for a wise Man will rashly affirm; nor do I believe neither, that there was ever any one found who would persist in this Notion, That we ought to ascribe the true and real Cause of the Formation of our own *Stamen*, or of any other Humane Body, to our own Knowledge, or to that of our Parents. Whoever, therefore, does any thing ignorantly and unknowingly, cannot, as we have said before, be consider'd any otherwise than as the instrumental, but by no means the true Cause of any Effect: From whence it follows, That the Conclusion must remain as it did; namely, that *neither our Parents, nor we ourselves, are the true Causes of our Existing here.*

SECT. IX. *That our Support is from Another.*

Now after the above-mention'd Discoveries, it may easily be made appear to every Man, that as he is not placed here by his own Power, so neither is he supported by the same: For if he were, he might at least provide Food and Nourishment for himself: But can he make the Sun to rise, which causes every Thing to spring out of the Earth? Can he bring down a Drop of Rain from Heaven, which renders the Ground so fruitful, and which likewise must serve him for Drink? Can he communicate an Existence, and the necessary Properties to one single Ear of Corn, or to the smallest Blade of Grass, in order to feed himself, and those Creatures which he uses for his Nourishment? But to go yet farther, supposing he had Food in abundance, can he tell after what manner his Body is thereby supported? Or does he know where that which refreshes his Body remains, as soon as it has passed thro' his Stomach
and

and Bowels, and how his Food is turned into Blood and other Juices, and how they again are converted into such different Parts, of which his Body consists? So that here again, he can conclude no otherwise, than that all this surpasses his Power, and that it is not by himself, but by some other Being, that he exists and is upholden.

SECT. X. *And this other Being, either knows, or is ignorant of what he doeth.*

NOW being thus far assured from what has been said, that a Man is not produced by himself nor by his Parents, but by some other Being, by which he is likewise supported; I leave any one to judge, whether he can live in a perfect Tranquility, without endeavouring to know what kind of Being it is, by which he is made and preserv'd; since I cannot think that he is so insensible, or so little affected concerning those Things that relate to his own Happiness or Misery, as not to look upon this to be an Affair of the utmost importance.

If then he will endeavour with us to enquire into these Matters, he must at least acknowledge for an undeniable Truth, that the Cause by which he is here placed and supported, does either know and understand its own Actions, or else is entirely ignorant of them; that is, he must either agree with the wisest part of the World, that there is a God by whom he is made and preserv'd, who knows what he did, and what he daily does, with respect to him; or else he must endeavour to persuade himself, pursuant to those Principles of unhappy *Atheists*, (which have never yet been demonstrated) that he was brought into the World by a meer and ignorant Chance, or by a necessary Consequence of the Laws of an unknowing

knowing Nature : One of these must be undoubtedly true.

SECT. XI. *That our Maker and Preserver is Wise, Mighty and Merciful.*

Now in order seriously, and without Passion or Prejudice, to consider so important a Matter, and to know which of these two Questions are to be received for Truth ; let him suppose, that he were to be brought into a Room, where he should see several Clocks and Watches that have been adjusted with all the Skill and Perfection the Artificer could exert, so that they went very true and regular ; and then let him ask himself, whether he thinks those Machines could acquire their Existence and Aptness to perform their several Functions, without the Concurrence of the Skill and Judgment of a Workman, and only by Causes that were ignorant of the Effects they produced, such as meer Chance, or necessary Laws of Nature ? and whether he would not judge that any Man, who should undertake to deduce such Conclusions from his own Philosophy, were not quite out of his Senses ?

After having maturely consider'd all this, let him proceed farther, and instead of Clocks, let him cast his Eyes upon the Frame and Construction of his own Body, or upon that of Beasts, Birds, Fishes, Plants, and other Wonders of Nature, and think, since a good Clock does undoubtedly prove its Workman skilful, whether in each of these last mentioned Things there does not appear an Art incomparably greater than that which shews itself in the very best Clocks ? forasmuch as it is most certainly true, that the best Artificer in the whole World, is not capable of producing even a Mouse or a Fly, a little Flower

or a Plant, tho' never so small, in such a Perfection as we see them daily appearing. Let him therefore silently examine himself, whether all his Atheistical Arguments can bring him to embrace these miserable Notions for Truth with Tranquility, and without a continual Remorse of Conscience, *viz.* that he who made his Body, and all these Things, after so wonderful a manner, and out of such improper Matter as the Earth appears to be for such a Purpose, should be so far void of Wisdom and Understanding, as not to know after what Manner, nor to what End, he had made the same?

Now since an unhappy *Atheist* seems to be unavoidably obliged by all these Things, to acknowledge that his Creator is wonderfully Wise; since, moreover, the Manner whereby he is preserv'd, seems to convince him, that this his Preserver is not only Wise, but also Mighty and Merciful; having most bountifully provided such a great Body as the Sun to give him Light; the Air surrounding this whole Earth, for Respiration; so great a quantity of Water, to assuage his Thirst; such a number of Plants and living Creatures, to satisfy his Hunger, and to refresh him; and so many other Things for other Uses, without any Co-operation on his Part, and such wonderful Faculties for the Enjoyment of them all: Let him finally consider with himself, what he ought to expect, even in his own Judgment, from the just Wrath of this his Maker and Preserver, in case he continues to deny his Wisdom, to despise his Power, and to be ungrateful for his Mercies; and in order to free himself from the Obligations he lies under to Providence for all these good Things, if he continues to ascribe them all entirely to insensible and ignorant Causes.

SECT. XII. *The Transition to the following Contemplations.*

I CAN scarce think it possible, that there should still be an *Atheist* so deplorably obdurate, after having weighed all these things most seriously by himself, as to dare to own, that the Consideration thereof does not make him uneasy; and in case there should be any that had so far abandon'd themselves to their seducing Passions, yet it is not to be imagined, that all of 'em have so greatly renounced their Reason, as not to think it worth their while to pass on with us to *the Contemplation of the Works of the great Creator* in the following Discourses; or that among so many Particulars and Wonders, which they will there meet with, there should not be one single one, sufficient to make them see their Error, and to give them a convincing Proof of a Deity shining out so brightly from thence. This I can say experimentally, that by the Meditation chiefly of what has been here offer'd in these two first Contemplations, an unhappy Person, whom I had formerly often besought, while he was in good Health, that he would seriously weigh these Things by himself, (and who was wont, even till a few Weeks before his Death, where-ever he could speak his Mind freely, to ridicule all such as acknowledged and served a God) was by God's Grace brought over to better Thoughts, and to a Conviction of his Existence, as he confessed to me with his own Mouth in his last Illness.



CONTEMPLATION III.

Of some Particulars in the Mouth.

SECT. I. *Concerning the Teeth.*

TO begin then ; let us first contemplate our own Body, and all the wonderful Structure thereof ; which, tho' the most part of our Food, as Bread, Flesh, Fish, &c. consists of solid Bodies, cannot be nourished by them so long as they remain such; and are not first converted into Fluids; wherefore a Means was requisite to turn these solid Bodies into a liquid Matter, and even such as should be proper to preserve and nourish us.

For this Purpose there are *Teeth* planted in our Mouths, of which those that stand foremost are sharp and cutting, in order to bite off a Part of that Food which is taken in, whose semicircular Figure is wisely adapted to a just Measure of the Piece to be bitten, and so as to be afterwards chewed with the most Conveniency, as every one may experience who makes his Biting greater or smaller. The second Sort are those that are called *Dog-Teeth*, and those are more pointed than cutting, and seem to be particularly designed for something that is tougher and harder, and which cannot easily be penetrated by the former, in order to hold it fast, and so to divide it from the other Part.

Does there not appear a wise End in all this ? Why are not the following Teeth, which are call'd Grinders, of the same Figure ? Why are they flat and

and broad, and uneven with Cavities and Protuberances, as if Nature intended, that what was bitten off by the foremost, should be beaten small and ground by these latter, to which their Unevenness contributes; as it is in some Mill-Stones that are made uneven on purpose, in order to grind the better? If this is done by Chance, why don't the Grinders stand foremost, and the Fore-Teeth in the inward Part of the Mouth, which would certainly render biting and chewing very uneasy? How happens it, that almost all the other Bones are clad with a tender and sensible Membrane, but the Teeth, so far as they stand out of the Gums, with none; unless it were to avoid that Pain, which the Use of 'em in biting would occasion, by pressing upon such a Membrane?

SECT. II. *Of the Enamel of the Teeth.*

CAN any one suppose that it is without Wisdom and Design (since the naked Bone can rarely endure the Air without Corruption, and the covering it with a Membrane would be here useless and inconvenient) that the Teeth are surrounded with a hard Substance, which the Author of the *History of the French Academy of Sciences*, for the Year 1699, p. 48. calls the *Enamel*; wherewith they are, as it were, glazed round about, so far as they are exposed to the open Air; and which as soon as they lose, they rot and are corrupted. In *Tab. I. Fig. 1.* you may see a Representation thereof: The Line A C F H is that Part of the Gums out of which the Teeth appear; A E C and F G H are the Roots of the Teeth: The Parts A D C B and F L H I I shew the *Enamel* or Glazing, which consists of small Fibres running parallel to each other, that joyn sometimes at

C 2

the

the Top, but below are separated from each other: This Enamel covers the whole Tooth as far as it stands out of the Gums: M M are the little Holes through which the Nerves pass into the Root of the Teeth of young People, but are closed in Old, as in N N; by which means this Part of the Nerves, which are otherwise in the Teeth, is separated from the remaining Nerves.

The Bone of a Tooth is remarkably harder than all other Bones, and is therefore thought by some to be of a petrified Substance, to the End that it might not become useless by Attrition. And whereas other Bones cease growing after a certain Age, the Teeth, or at least their Enamel, increases even to old Age, in order to make good the continual wearing of 'em: this appears when we lose a Tooth out of one of the Jaw-bones, that which is opposite to it in the other, becoming oftentimes longer than those which are next to it.

SECT. III. *Of the Lips.*

To say no more of other Uses of the Teeth, with respect to the Beauty of the Countenance, and particularly for Speech, which by their means becomes intelligible, easie and distinct: Who can consider the Structure of the *Lips* without Astonishment, and their Motion in such various Manners? The Opening of them for the Reception of Food; the Closing of them again to prevent the same Food, whilst it is chewed, from falling out of the Mouth; the Use of 'em in Humane Speech; by these the Children suck their Mother; and these, together with the Tongue and Cheeks, are useful in chewing the Food, which not being able to remain under the Jaws and Teeth, is by them, at every

every turn, brought back again, till it becomes small, and sufficiently moistened by the Spittle.

SECT. IV. *Of the Glands of the Mouth.*

Is it not likewise by a wise Contrivance, and not by meer Chance, that there are in the Mouth so many Glands or *Fountains of Spittle*? Since if the Food should remain dry, it could not be swallowed down, but with a great deal of Trouble; whereas the Moisture that proceeds from them by innumerable Orifices, is mingled with Food whilst it is chewed; and this Liquor, or Moisture, is brought thither by long Vessels, and distant Glands, not only to the aforesaid End, but (which is more) to give an Occasion for the more easie converting the solid Food, wherewith it is mixed in the Mouth, into a nutritious liquid Substance in the Stomach. We shall not here mention the Property of *Spittle*, in causing many Things to ferment, or other Qualities, which may be found in the Writings of those who have enquired into them, because we will not dwell too long upon this Subject.

SECT. V. *Of the Tongue.*

BEFORE we take our Leave of the Mouth, I cannot forbear observing something more therein, which every one that sees the Effects of it, must needs be astonished at; this is the wonderful Structure of the Tongue: And here I would freely ask all the Artificers in the World, whether any of them could have invented such a Machine, which having neither Bones nor Joynts, can produce such an innumerable Variety of Motions; sometimes making itself long and thin, at other times short and thick; and in a Minute stirring

and turning itself after so many particular Ways, that one can scarce fancy any kind of Motion of which it is not susceptible?

Can any body think that there is neither Understanding nor Wisdom made use of here by Him who has formed such a wonderful Body, only by the knitting together of some Muscular Fibres, (if we except some Glands, the Use of which is to moisten it, as it becomes dry) and fix it in a Place where all these Motions may have their Use?

Let the most obdurate and deplorable Atheist consider with himself, whether there is the least Shadow or Appearance of Truth for his ascribing this to meer Chance, or to natural Laws working necessarily, and without any wise Determination.

This Tongue lies in the Mouth, where the Sound that comes out of the Wind-pipe passes thro'; and which, by the Motion of the Tongue, becomes distinct; and so forming all Speeches and Languages, produces this great Wonder, that a Man, by the Motion of such an Instrument, can communicate the Thoughts of his Soul to another; whereas, if it were otherwise placed, or if it were not of such a Texture and Property, the whole World would be brought into Confusion: This may be observ'd in those, who by Deafness or other Accidents have the Misfortune of not being able to use their Tongue: How great is the Trouble and Difficulty they find in expressing their Thoughts to other Men? In short, every one may easily represent to himself what a Disorder it would be, supposing all Men dumb, if we were obliged to make use of other Signs and Tokens, in order to carry on any Commerce or other Business with one another; not to mention the Prejudice which the teaching of all Sciences,

Sciences, and in a manner every thing that passes among Men, would suffer thereby.

The Tongue does also lie upon that Place, thro' which the Meat and Drink passes; and besides its other Faculties, is a principal Instrument of Taste. If it had not this Property, how many People would eat without any Pleasure or Satisfaction? Nay, so necessary a Work would be very tedious and irksome to many.

Can any one again persuade himself that he is not beholden to the Wisdom and Goodness of his Creator, who has placed this *Tongue* in the *Mouth*, and endow'd it with all these Properties? Could any Man ever show in the very best Machine of Humane Invention, so many Wonders in the Structure thereof, so much Wisdom in the Disposition of the Parts, so many Advantages in the Use of it? And can all discover the Hand of a wise Artificer in the Formation of a much meaner Instrument? How miserably blind are such Men, who cannot see in this wonderful and amazing Structure of the Tongue, a Wise, Powerful and Gracious Creator, and still presume to affirm that all this comes to pass by Chance, at least without Knowledge?

Not to mention here expressly that Service and Use of the Tongue which preserves all Men alive, viz. by thrusting the Food, after it has been chewed in the Mouth, down the Throat; without which we should not be able to swallow at all, or at least but with great Difficulty; the Inconveniencies of which, all such as have lost this Faculty by Swellings in those Parts, are very sensible of.

SECT. VI. *Of the Throat.*

NOW if we pass on to the Throat, whither the Food leads us from the Mouth and Tongue ; and if we consider the Structure thereof, can any one imagine that it was so contrived without any Wisdom, that the Orifice, or Opening of the Throat, is dilated by three Pair of different Muscles, (see *Tab. I. Fig. 2. B B, C C, D D,*) like a Bag by six Hands, to the End that the Food, which the Tongue drives thitherwards, may be swallowed, and descend without any Trouble ; being drawn up so much higher backwards, by the Muscles D D, that the Food passing over the lower Brim thereof, and striking against the hinder Part, should not fail to find the right Entrance of the Throat, which being composed of a moist Membrane, would close together, or at least hinder the swallowing, if those Muscles were not placed there.

SECT. VII. *Of the Wind-pipe.*

BUT herein appears yet more sensibly the Design and Wisdom of the Great Artificer, in ordering the Food to pass over the Orifice of the Wind-pipe as it goes to the Throat : For if any thing falls into the Wind-pipe (which People commonly call *going the wrong Way*) every one knows what Disorder it occasions in them, so great sometimes as to put them in danger of choaking ; wherefore it is absolutely necessary, if we would eat with Ease, and preserve our Life at the same time, that the Wind-pipe, or the Mouth of it, should be closed when we swallow, and then immediately open'd again in order to draw our Breath : Now can any body be so dull
as

as not to observe this determinate End and Design of our Wise and Merciful Creator! Let him only take the Trouble of viewing the upper Part of the Wind-pipe of a Sheep or a Calf, where he will see more plainly than can be shewn him here by a Figure, that there lies a Cartilage, called the *Epiglotti*, which being pressed down by the Food, when 'tis swallowed, covers the Orifice of the Wind-pipe lying under it, by which means the Food passing over it, as if it were a Bridge made for that Purpose, in its Way to the Throat, is prevented from falling into the Wind-pipe, which would often occasion coughing, straining, and other greater Inconveniencies.

Now if this Cartilage should remain lying thus upon the Orifice of the Wind-pipe, the Breath would be stopt, and the living Creature immediately suffocated. Do we not here again discover a wise Design, that this *Epiglotti* is so contriv'd, as to rise up like a Spring that has been pressed down, or as some say, drawn up by Muscular Fibres after the Food has passed over it? By which means the Passage of the Breath is immediately open'd after swallowing, in case the Elastical Force of the said *Epiglotti* should be weaken'd by too much Use.

SECT. VIII. *Convictions from what has been said above.*

Now let a Man consider all these things together, as they appear in so small a Place as the Cavity of the Mouth, and see whether he can still suppose that all of them, so manifold in Number, so necessary to our Life and Well-being, could have met together in such a narrow Circumference, without any Design of the Maker, and by meer Chance or ignorant Causes? Can he not clearly discover therein a Wisdom, Power and Goodness,

Goodness, which contrived all this, in order to support this Part of the Humane Body, and to preserve it from sudden Death by Suffocation or Strangling? And let any one say, if he can, that in a Place not above a Span long, where so many Dispositions of so many different things, for the attaining such weighty Purposes do appear; that all this is brought about, by Causes ignorant of their own Work.

SECT. IX. *About Sucking, and of Places from which the Air is exhausted.*

BEFORE we conclude this Discourse, I must add something, which as often as I consider it, does every time excite in me a new Astonishment.

All the Learned World knows the just Praises that have been given to the famous *Terricelli*, *Gueric*, *Boyle*, and others, who were the first Inventers of the Art of producing a *Vacuum*, or Place void of Air, by the subsiding or sinking of Quick-silver, or otherwise by Air-Pumps, whereby so many Secrets of Nature have been discover'd. And can we see without standing amazed at the All-comprehending Wisdom of our Great CREATOR, who has prepared and fitted the Mouth of all Men for an Instrument to produce the same Effect! The Action which is called *Sucking*, is a plain Demonstration thereof, and is performed by putting the Tongue and Lips together, or otherwise, only by leaving a little Cavity between them first open, and afterwards drawing the Tongue backwards, which makes a Hollowness that was not there before between the Tongue and Lips, and consequently empties it of Air; or otherwise, by drawing the Tongue back, makes the Cavity that was there larger, giving the Air that was in the Place more room,
and

and so lessens the Pressure and Resistance of it in that Place ; by which means the Liquor (into which one End of a Pipe is put, and the other into the Cavity of the Mouth, which has been emptied of its Air) being pressed by the External Air, and finding in the Mouth little or no Resistance, is forced up thither. The same Effect is seen in the Sucking up of Smoak by those that take Tobacco.

SECT. X. *Sucking, as performed by Children.*

BUT that which ought to be not only surprising, but astonishing to every body, is, that this so artful a manner of producing a *Vacuum* is performed by Children newly born, and even by all the most irrational Creatures, which, by Sucking their Dams as soon as they come into the World, are already taught to begin to support their own Lives. Can these know that the Air has an expansive Faculty? That it presses all things with so great a Weight? That to cause the Milk to come out of the Breast with such a Pressure, there must be a *Vacuum*, or Place void of Air, made before the Orifices of the Nipples? That this Place must be so closed on all Sides, that tho' the Air, in order to Respiration, passing thro' the Nostrials, can insinuate itself by the smallest Opening, yet it must be prevented from coming into this *Vacuum* ; for in such a case the Sucking, or the flowing of the Milk, would cease ; all which things must be well observ'd by such as make Instruments proper for Sucking, as they are exactly followed by Nature ; which teaches ignorant Children, and even brute Beasts, to form this curious Machine, and to use it according to the strictest Rules of Art.

SECT. XI. *Convictions from the foregoing Observations.*

Now let the unhappy Patrons of the desperate Sentiments of an *Epicurus* and *Lucretius* seriously consider these things with us, and see whether their Fundamental Principle can obtain here, *viz.* that all things are produced without a certain End or Design of the Creator, and that Men only finding 'em so prepared to their hands, do make their Use of them. Is it to be believed that this can happen with Children, and all other Creatures, as soon as they are born, which do not so much as know that there is such a thing as Air, much less how to apply it to this Purpose? Can any Man, endow'd with Reason, think that the dullest and most ignorant of all living Creatures are immediately capable to apply such a Machine to its right Use? Whereas Men of the greatest Learning and Understanding will readily own how difficult it is at first for them to understand and use the same rightly; every one can witness this the first time he takes an Air-pump into his hand.

And to give a convincing Proof that the Instruments made use of for Children and young Creatures in Sucking, are produced by infinite Wisdom for that Purpose, we need only enquire into the wonderful Structure of the Muscles of the Lips and Tongue, and the fleshy Fibres of which they are composed, and which are so well describ'd by all skilful Anatomists. If we would allow Reason to take place, we should be sufficiently satisfied by this single Instance; that, because that Passage is stopt in Sucking, which upon other occasions is prepared for the Air, the adorable Creator, and
great

great Preserver of all things living, has so disposed the Nostrils, that they may serve for breathing during the Action of Sucking; and so this great Work, so necessary to new-born Creatures, might not be obstructed at every turn. A Proof of this is seen in Nurses, who, when they have a mind that the Child should leave off Sucking, stop their Nose with their Finger, by which means their breathing that way being hindered, they immediately quit the Breast, that they may draw in the Air by their Mouths.

How desperately blind must he be, who in all this does not observe the Wisdom of his Creator! that has after so wonderful a manner contriv'd this so great and so necessary a Work, whereby all living Creatures are, as soon as born, preserv'd from perishing for lack of Food, even then when the Nature of *Suction* was unknown to Mankind? For it is plain, beyond all need of Proof, that none of the old Philosophers (as far as appears by their Writings) knew any thing of the matter, till that in the last Century the Properties of the *Air* were discovered.

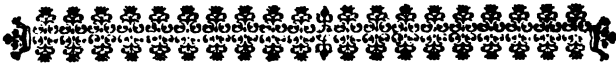
Since it is not conceivable, how any one can have a just Notion of the Nature of *Suction*, without owning at the same time the amazing Wisdom of him who (to say nothing of Womens Breasts) has adapted the Mouths of Children to perform a Work of so much Art; could any Man likewise behold a Machine form'd for making a *Vacuum*, or for exhausting Air, not composed of any solid Matter, such as Brass, Iron or Glass, (of which Air-pumps and Barometers are usually made) but only of flabby Membranes, and flexible Fibres joyn'd together, such as the Muscles are made of; I say, could any one see these Wonders perform'd by such Instruments,
and

and imagine them to be form'd without any Skill in *Mechanicks*, by meer Chance, at least without Wisdom or Design?

Let the most obdurate Atheist, even tho' he were a great Mathematician, set about a Work of the like Nature, and try whether with all the Skill he is Master of, he can produce so compleat a Machine out of such unapt Matter; and if he could frame one, even after a much more imperfect manner, would he not think that such an Invention ought to procure him the Praises of the greatest Mechanists? And can he then think himself Just or Reasonable, to refuse those Praises to that Glorious Creator, who has placed and fixed such a Machine in the Mouths of all Men, and of many other Animals!



C O N-



CONTEMPLATION IV.

*Of the Throat, Stomach, and Bowels.*SECT. I. *Concerning the Throat.*

LET us now go on, and contemplate the Structure and Function of the Throat, as it extends itself from the Mouth to the Stomach.

The Food being sufficiently chewed in the Mouth, and being conveyed in the manner as has been before described, into the Throat, thro' the Orifice or Opening thereof, (*Tab. I. Fig. 2. E*) if it were to descend by its Weight only, it would require a great deal of Time to pass into the Stomach thro' this Tube, because of its being membranous and moist, so that the Parts of it would stick together; especially, if any Piece of Food, by its Largeness and Solidity, should extend the Throat in its Descent, and thereby contract those Parts that are above and below the said Food: To say nothing of the Throat of Beasts, which lies horizontally, or even ascends when they feed upon the Ground; in such a case, I say, that which is swallowed would not be able to proceed into the Stomach.

Now, to prevent all these Inconveniencies, it has pleased the Gracious Creator to place there a Muscle, A A, (which is here represented, cut thro', and is by some taken for two) the Fibres of which encompassing the Throat, and contracting themselves, do thereby squeeze it, and so force the Food to descend; for whatever the Cause be, it is
expe-

experimentally true, that all the Muscles of the Body operate, by contracting or shortning their Fibres.

SECT. II. *The Strait and Circular Fibres of the Throat.*

CAN we further consider the wonderful Order in which this Tube is framed, without acknowledging a Wisdom therein that intended the Protrusion of the Food into the Stomach! Since the outward Membrane E being taken off and laid aside at *a* (which is to be understood in all those Places where you meet with the Letter *a* in this Figure) the Muscular Fibres F shew themselves, descending perpendicularly, or lengthwise, according to the whole Extension of the Throat; having others under them, as in G, which encompass the Throat like Rings or Circles: Let us now imagine, that these two Sorts of Fibres, viz. those that run lengthwise at F, and the Circular at G, were contracted; we should then perceive that these last Circular Fibres, shortening themselves behind and above the Part where the Food lies, protrude the same downwards, after the same manner as the Women that make Sausages are wont to do, by squeezing the Matter with their Hand, in order to make the same go forward into the Bag or Gut that is to contain it; whilst in the mean time, the long Fibres, by shortening themselves likewise, do widen the Place thro' which the Food is to pass, to the End it may be the more easily thrust down by the Contraction of the Circular Fibres.

Now that this Motion and Progression of the Food towards the Stomach is perform'd by such a kind of Force, and not by its own Weight, is plain by Childrens swallowing their Victuals into
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the Stomach upwards when they stand upon their Heads: Upon which Account every one of us is most highly obliged to the Goodness of our Creator; because otherwise no body could take in any Food in the Posture of lying down; which how exceeding inconvenient it would be to sick and distemper'd People, is not necessary to be farther described.

SECT. III, *Of other Tunicles or Coats of the Throat.*

ONE thing further seemed requisite towards rendering the Passage of the Food yet more easy, viz. That the Tube above-mention'd, for the better performing its Function, should be kept constantly moist; forasmuch as the Food being sometimes dry, its Motion and Descent would be perform'd more slowly and with greater Trouble.

Can we therefore discover no Wisdom herein; that in order to produce such an Effect, the said Throat has a Tunicle full of Blood-Vessels, that is of Veins and Arteries, (See *Tab. I. Fig. 2. H.*) and yet another under that at I, which is called the *Glandulous Tunick*, because it is full of little Glands, from whence a Liquor is separated from the Arteries, which renders the under-lying K, called the *Nervous Coat*, smooth and slippery, that it may be fit for the said Uses? It ought likewise to be observed here, that these Glands in this Coat or Tunicle are placed exactly between fleshy Fibres for this Reason, that thereby they may be more or less pressed, in order to discharge their Moisture according as there is occasion; for which Cause likewise, this last Tunicle is endued with a soft Wooliness on the Inside, which in some measure is able to stop and

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hinder the Moisture from passing away till it has performed its Function of making the Parts slippery; when there is too little of this Moisture, and the Throat is too dry, that which we call Thirst, seems to be produced, which is a natural Warning that Moisture is there wanted.

SECT. IV. *Convictions from the foregoing Observations.*

Now can any one imagine, that all this wonderful Structure of the Parts of the Throat is produced by Chance, without any View or Respect to the Order and Uses for which they are designed! which besides those artful Instruments for forcing the Food to descend into the Stomach, besides the Veins that feed it, and by the Moisture which is separated in the Glands, contribute to make it smooth, has likewise in itself the Property of warning us when we ought to moisten it, at such Times as its own natural Juices are not sufficient to perform the same, by reason of the Dryness of the Food, or other Accidents: And if any Body does persist in affirming that all this is owing to Chance, why should he be ashamed to say, that a Spout or Pipe, by which the Rain-water is conveyed from the Top of a House into a Cistern (which in comparison of the Structure of the Throat, has nothing of Skill in it) was produced in that Place by a meer Accident, and without any End or Design?

SECT. V. *Of the Stomach.*

Now in case the Stomach DCDT, (*Tab. I. Fig. 3.*) were as narrow as the Throat EA, or as the Intestines GHHI, both which make one and the same continued Tube with the Stomach, and that the Food should pass thro' all of them
with

with equal Force and Swiftneſs, it would not be poſſible that the ſame ſhould be rightly prepared, or, as they call it, macerated and converted from a ſolid Body into a fluid Matter proper for Nouriſhment.

And here again do we not ſee plain Footſteps of a wiſe End in contriving the Stomach to be ſo much larger and hollower, in order to contain at once all the Meat and Drink that is ſent down into it? and beſides of ſuch a Structure, as not to ſuffer the ſame to paſs too ſoon thro' it, as it happens in all the other Parts of this great and long Tube?

Thus we ſee that the Food deſcending from E. A. into the Stomach B, is hinder'd from proceeding further, by Reaſon that the extreme Part or End of the Stomach C, by which the Food is to be diſcharged, is ſo much higher than the Belly of it in which it lies; whereby it is obliged to remain there for a while, in order to be turned into a ſort of Pap, which the *Anatomists* call *Chylus* or *Chymus*; or as ſome will have it, till the Quinteſſence thereof be extracted.

And what I cannot paſs over here without a Note of Admiration is, That according to the Obſervations of that great Anatomist *Verheyen*, the diſcharging Part C is not-raiſed up to that height, but juſt at the Time when the Stomach is full and extended, and ſo is capable of hindering the Food from paſſing too ſwiftly thro' it; whereas otherwiſe when the Stomach is empty, it ſinks down much lower. Can any one ſee this without diſcovering the Deſign of the Great Creator, to continue the Food a ſufficient Time in the Stomach!

SECT. VI. *The Juices of the Stomach, and concerning the Muscular Valve.*

NOW whether the Consumption of the Food happens after one or the other Manner, it was necessary in both Cases, that there should be more Moisture mixed with it in the Stomach, in order to put it into a Fermentation, or otherwise to convert into that fluid Matter called *Chyle*.

Can it now be thought, that meer Chance produced such a vast Number of Arteries in the Stomach as you may see at DD, dd; and such a wonderful Number likewise of Nerves, spreading like so many Branches out of E and F, which convey into it such a Moisture and Nervous Juice by the Glands that are placed on purpose, that together with the Spittle which is mixed with the Food in Chewing, they may make a new Liquor proper for the Attrition or Breaking of the Food; and to the End that it may remain long enough therein, the extreme Part of the Stomach B (*Tab. I. Fig. 4.*) is shut up with a Muscle that encompasses and contracts the same, and which therefore cannot be opened but with a greater Force or Pressure?

SECT. VII. *The Fibres of the Stomach.*

THE Food having remained some Hours in the Stomach, in order to its Change, must afterwards pursue its way for the Nourishment of the whole Body: Can any one then think that it happens without the especial Wisdom of GOD, that every Thing is found in the Stomach adapted in the best manner to promote this Purpose?

1. By

1. By the insensibly oblique Ascension from the Bottom of the Stomach to the Passage C (*Tab. I. Fig. 3.*) in order to discharge the same: Whereas if this last Orifice was of the same Structure as that at A, thro' which the Food passes into the Stomach, it is plain that the Discharge thereof could not be performed but with very great Trouble.

2. Add to this, that the external Fibres of the Stomach are extended lengthwise in it, and being shorten'd in their Operation, they likewise render the Stomach so much shorter; and in order to exert themselves with greater Strength at both the Orifices A and C, as also at the Bottom of the Stomach, they become musculous.

3. Moreover (*Tab. I. Fig. 4.*) other stronger Fibres D encompass the Stomach annularly, and cross the former, which being drawn together, make the Stomach narrower.

4. Under these there lie yet another Row of Fibres (*Tab. I. Fig. 5.*) which run obliquely A, extending themselves from the uppermost Part of the Stomach to the Bottom thereof, drawing obliquely the End M towards the Beginning N.

Now let any one suppose, that he held this Stomach CT full of a fluid Matter in his Hand, and that it was to continue in the same Position in relation to the Height of its lower End C: Could he possibly invent a better Way to discharge the said Matter by the Orifice C, as first by closing the Orifice A, and afterwards contracting the Stomach, by pinching it together lengthwise from C to A; by which means the inclosed Matter being thrust against the Left end of the Stomach T, must necessarily be forced out at the Right end where the Orifice C is?

Now how particularly serviceable the strong Muscular Fibres B (*Tab. I. Fig. 3.*) are thereto, is plain, *first*, because they encompassing the Left Orifice of the Stomach I, do shut the same exactly at the Time when the Food is thrust out at the other Orifice K, to the End that the Chyle may not be driven back again into the Throat thro' the Orifice I P. *Secondly*, Because these Fibres B running lengthwise, are inserted in the right Passage of the Stomach K, which when they become shorter, they draw towards themselves, and by this one Action do at the same time contract or shorten the Stomach from M to N, and whilst they shut one Orifice I, they do in some manner dilate the other K; insomuch that it is impossible, when all these Fibres are contracted and perform their Function, but that the Chyle should be protruded by the Orifice K K.

How comes it to pass now, if all this be done by Chance, that these Fibres of the Stomach run, or are extended so differently from those of the Throat, and those of the Bowels, which shall be accounted for hereafter? And whence comes it, that each of them is adapted, in the most proper manner, to its right Use, and the Functions that are required of it? Can the wonderful Structure of the Fibres be deemed accidental! Why don't they say the same of the Preparation of the Ropes that are used in the drawing up of a * *Rammer*, in which, comparatively, there is very little Art?

* An Engine used in driving Piles or Stakes into the Ground.

SECT. VIII. *The Mucilage or Slime of the Stomach.*

BESIDES all this, there is often a Necessity in some Persons, for an Acid Matter to compleat the Dissolution of some kinds of Food; of which Nature are also several Medicines, such as Vinegar, Verjuice, Lemon-Liquor, Mustard, Pepper-Root, and almost all Spices, all Salts, as well the Common as Volatile, and others, which are all Acid, and nevertheless very necessary on some occasions. Now, forasmuch as the Stomach is membranous, and the Membranes thereof extremely sensible, there was danger, that by such sharp Matters it might either be affected with Pain, or else irritated to Vomiting or other irregular Motions. Can we therefore here, without Thankfulness and Astonishment too, observe, how it has pleased our Gracious Creator, with great Wisdom to provide against the same, by cloathing the innermost Part of the Stomach and Bowels with a thick and tough Slime, (whereby they are defended from the Corrosion of those sharp Matters) which is stopt there, and adheres to small Fibres, that stand streight up on the sides of the Stomach, like the Silk Thread in Velvet, to prevent the said Slime from being carried away immediately by the Food that passes thro' the Stomach!

Can any body now, considering what has been here said about the Stomach, (tho' for Brevity sake I have designedly omitted several remarkable Circumstances) remain unconvinced that it was a Great Creator who, in order to display his Wisdom and Goodness to Mankind, has produced all this in such a beautiful Order! And can he, without Scruple, ascribe this whole Structure to ignorant Causes! the rather, because any one of these Circumstances failing, very dismal Conse-

quences, and even Death itself, would sometimes follow.

SECT. IX. *Of Hunger.*

To say nothing more about the Stomach, which seems plainly to prove the Design of Him that made it; are we not particularly obliged to return him our Thanks for having been pleased, over and above, to add to the Structure of the Stomach, besides so many other necessary Uses, the following Property, *viz. Hunger*; by feeling which, we are acquainted, that we stand in need of new Food and Refreshment, of which, without such a Warning, we should not be sensible oftentimes, till we become weak and faint, and unfit for Business for want of the same.

He must be miserably blind who cannot discover a Wise and Gracious Maker of all these things; or that can persuade himself, that their skilful Structure, and so many Conveniencies and regular and well adapted Uses, can be produced by meer Chance or irrational Causes.

SECT. X. *The Uses of the Guts.*

LET us now pass on with the Food to the Bowels or *Guts*; to know the Construction of which, you may consider the Tube (*Tab. I. Fig. 2.*) representing the Gullet and the Stomach as Parts of the Bowels to which they are annex'd, since the Membranes and Tunicks thereof are for the most part analogous with those of the Guts, and so are its Motions too, by which the Matter contain'd therein is protruded; for which reason we shall not repeat the same here.

This Tube has the following great Uses; (*Fig. 1.*) *First*, that it separates that which is proper for Nourishment from the unnecessary Parts, conveying

ing it to the *Vena Lactea*, or Milky Veins; *Secondly*, that it carries the Remainder of the Food to the *Intestinum Rectum*, in order to be there discharged.

Now to speak of this last in the first place, it will not be necessary to say, after the Description of the Gullet and Stomach, that this is also performed by the long and circular Fibres, which do likewise both here produce, by contracting and shortning themselves, a protrusive Motion, called by the Anatomists, *The Peristaltic Motion*.

SECT. X. *The Mesentery.*

You may see how these Bowels are placed in the Body, in *Tab. I. Fig. 3*. Now in case this Tube of the Bowels was short, there would be danger that the Chyle, or nourishing Juice, extracted from the Food, might in a great measure be discharged with the useless Part thereof. Is it therefore without a Design of the Maker that there are so many Meanders or Windings therein; so that it is very near six times the Length of a Man? And particularly, that notwithstanding all its Turnings, it is fasten'd in such a manner to the *Mesentery*, that it is not possible for the Food either to mistake its way, by reason of the length of the Intestines, or to take any such turn, as that the way thro' which the Chyle passes should be stopt; as may be seen in *Tab. I. Fig. 6*. where G G represents the Mesentery, and L L the Bowels or Guts fasten'd to it, but both extended.

Now can any one see without Astonishment, that in this Membrane (which being only flat and round, would be too big to lie conveniently in the Belly, in case it should be fasten'd to such a great Length of the Bowels in its Circumference) such a wonderful Method is used by our most wise Creator for that purpose, *viz.* by plaiting it upwards and downwards upon the Edge of the Mesentery,
just

just as they used to do the Ruffs in old Times? An Instance of which may be seen in that Part of the Intestines described by P Q, R S, (*Tab. I. Fig. 6.*) and more fully in the 2 *Fig.* of the 18 *Tab.* of *Verheyen*, in the ruffled Edge BB of this expanded Mesentery; to which, that we may not multiply the Figures too much, we refer those that are desirous to see it in its true State. It is by this means, that tho' the same is not above two Spans breadth in a Man of a middle Size, yet by these Plaits and Folds it acquires so much Length, as to afford sufficient room for the Tube of the Intestines, which is so much longer, to be fasten'd to it. Now in case this Problem had been laid before a great and able Mathematician, would not he have thought that he had acquired no small Honour, by solving it after this manner? And can any body fancy that this is performed by Chance, or without Wisdom!

SECT. XII. *The Glands of the Intestines.*

NOW whilst the nutritious Juices are continually separated from the Food in the Bowels, and by Openings, which are found in their Membranes pass into the external Parts, as we shall shew hereafter; it seems as if it could not be avoided, that the Remainder being thereby become dryer, should be hinder'd from proceeding conveniently on its way in this Tube. To remove this Difficulty, the adorable Creator has been pleased to place several Glands in the Intestines, from whence they filtrate a Liquor sufficient to soften the Excrements, besides others proceeding out of the Glandulous Coat of the Bowels themselves, which help to render the Passage smooth and slippery, and so fit for the intended Service.

Can

Figure 1

E

D

C

B



1. The first part of the document is a list of names.

2. The second part of the document is a list of names.

3. The third part of the document is a list of names.

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Can this likewise be said to be done by Chance! Why then are these Glands smaller and fewer in the thin Guts G, H H, I I, (*Tab. I. Fig. 3.*) which lie next to the Stomach, where that which is in it has a great deal of Chyle and Moisture? And why are those Glands multiplied about the End of these thin Guts, unless it were that the useless Matter, being by the Separation of the Chyle grown dryer, wants more Moisture to render it so fluid; and to the end that what still remain'd in it of the Chyle may be squeezed out of it; after the manner of the Apothecaries, who, in order to extract the Juices from their Drugs when they are pretty dry, put some Liquor in, while they are pounding them? Lastly, why are those Glands in the thick Guts M, N N N, O, that lie farthest from the Stomach, and where the Matter to be discharged is in a manner divested of all its Chylous Juice, the biggest of all; unless it be, that the greatest Moisture is there requisite to prevent its being too hard?

SECT. XIII. *The Wrinkles, Valves, and Intestinum Rectum.*

Now not to mention the Wrinkles of the thin Guts, the Use of which is to hinder the digested Food, that has still some Chyle in it, from passing too swiftly thro' those Orifices that are made to receive the Chyle, nor the great Valve K, at the end of those thin Guts, whereby the Matter that is hardly now of any further Use, is hindred from going back: Why are the thick Intestines larger, and furnished with so many separated Places, unless it be to collect the useless Matter therein, and to the end that People may not be too frequently obliged to discharge the same?

Is

Is it not therefore very plain, that the *Intestinum Rectum* O P, is only contrived for discharging the abovesaid Matter? Why does it descend straight forwards, unless it were, that the Discharge of the said Matter should not be obstructed by unnecessary Windings and Turnings?

Is all this made without such a Design! Why is there a round contracting Muscle P, which, like a Ring, pinches this Bowel at the end of it? Is it not to hinder an incessant Protrusion of the Excrementitious Parts, by the continual Peristaltic Motion of the Intestines? And since that in several Discharges, when the Matter is hard, the *Intestinum Rectum* O P, is pressed and sinks downwards, we may see that the two Muscles Q P and Q P, are placed there on purpose to secure it; for by their Assistance, the shutting Muscle and the *Intestinum Rectum* are drawn back again, after a difficult Discharge, and made to ascend by the shortning of their Fibres.

SECT. XIV. *The Uses of the Oblique and Lateral Muscles of the Belly.*

AND forasmuch as the Protrusive Motion of the Bowels is not sometimes strong enough alone to discharge the Excrementitious Matter, ought we not likewise herein to adore the exceeding great Wisdom of the Creator, who, besides the *Diaphragma* or *Midriff*, has after so wonderful a manner made the whole Covering, or Tegument of the Belly, to be assisting thereto; by which means the expulsive Force may be render'd incomparably greater, as often as there is any occasion for it?


In order thereto, People are wont, first, strongly to draw in their Breath; by doing of which the *Midriff* lying just above the Stomach, so violently presses

presses upon all the Bowels, so that unless they oppose it on purpose, the whole Belly riseth therewith, to the end that the Guts may be pressed more closely together.

Now since the Bowels, thus press'd down by the Midriff, are forced to dilate themselves outwardly in the Belly, unless the extended Covering of the Belly did again contract itself by the Action of its Muscles, and press the Bowels together with a strong Force, the Excrements cou'd not be protruded thro' the *Intestinum Rectum*: But since that Intestine is open, and at the same time the Bowels are press'd together from all Parts, the Matter contain'd in them must be protruded thro' the Orifice of the said *Rectum*.

Now how wonderfully this comprehensive Force is produced by the Muscles which compose the Coverings of the Belly, is plain to those that are acquainted with the Structure thereof.

To give you some Notion of it here, without mentioning the usual Coverings which the Belly has in common with many other Parts; (*Tab. II. Fig. 1.*) A is the *Cuticula* or upper Skin, B the *Cutis* or Skin, C the Fat, D the fleshy Tegument or Covering; the external Parts thereof to consist, on both sides, *first*, of the Muscle G, the Fibres of which descend obliquely from the *Vertebra* of the Loyns to the *Linea Alba* K K, which runs downwards from the Breast-bone thro' the Navel L to the *Os Pubis*, and is of a strong and fibrous Structure, in order to resist the Force of the Muscles drawing against one another on each side: The Muscle of the same Name and Kind belonging to the other side, is laid open at O, in order to shew that which is under it. *Secondly*, we see another pair of Muscles lying under the former, the Fibres of which running upwards obliquely from the *Vertebra* to the aforesaid *Linea Alba* K K,

K K, do cross those of the first Muscle ; as appears here  M, on the one side, under a part of the first Muscle, which is turned up ; and on the other side at P, where it is fully separated. *Thirdly*, There are a pair of Muscles that lie underneath the same, on the right side at U, the Fibres of which are extended laterally or cross, and not obliquely, from the *Vertebra* to the *Linea Alba*, or White Line K K: The transverse Muscle of the left Side is not visible in this Figure, because of the Muscles that lie upon it, called the *Lateral*.

Let us now suppose that these two lowest lateral Muscles V, do encompass the Belly quite round, and in that manner compose a Cavity, which contains the Bowels ; and further, that all the Fibres of which they are made up, are shorten'd or contracted : It is plain, that the Cavity has thereby a lesser Circumference, and consequently must be narrower ; and so the Bowels therein contain'd will be pressed together on all sides.

But since those Muscles are not only serviceable in the Evacuation of the Bowels, but likewise of the Bladder, and even in the Labour of Child-bearing Women, to whom they are of the greatest Use in that important Case, it was necessary that this Pressure should be performed with very great Force ; for which Reason the wise Creator has placed another pair of Muscles (one of which is represented by M) upon the *Lateral*, the Fibres of which running obliquely upwards, as is said before, and ending in the *Linea Alba* K K, when they operate and become shorter, do in like manner contract the Belly ; but they do also at the same time (as is well known to the Mathematicians) by their Obliquity extended upwards, as it were draw down the whole *Linea Alba* K K. Now to obviate the Inconveniencies that might proceed from hence, the Fibres of the Muscles G, that

that lie upon these, do run with a quite contrary Obliquity downwards; whereby the Belly is not only contracted with a new Force, but the *Linea Alba* K K, is again drawn upwards by this contrary Obliquity.

SECT. XV. *The Use of the Pyramidal Muscles.*

NOW if each Pair of these last oblique Muscles operated with like Force upon the *Linea Alba*, and that the same was drawn as much upwards by one Pair as downwards by the other, they would balance one another; and this White Line K K, would remain in its Place, without moving one way or the other: But since these last and uppermost descending Muscles G, are much larger and stronger than those that lie under at M, it must follow, that whilst they operate together to discharge the Belly, by this over-balance of Force, these Fibres or White Lines K K, will be constantly drawn something upwards.

Can it now be brought about by Chance, that we meet with a Pair of Muscles S and T, under the *Os Pubis* (the last of which T, is shewn separated, and hanging downwards out of its Place) which, from the Figure of them, are called *Pyramidal*, and whereof the Fibres do only run upwards along the White Lines to K, or about as high as the Navel; so that it is very plain to every Body, that being shorter at S, and consequently their Fibres being drawn downwards, the *Linea Alba*, to which the Fibres are fasten'd, must likewise follow downwards; and therefore these *Pyramidal* Muscles seem to be made use of as a Balance of the Force, by which the descending oblique Muscles at G, do exceed the ascending oblique ones at M; and whereby, if not prevented by the *Pyramidal*, the White Lines would otherwise
be

be mov'd upwards? This Opinion is confirmed; forasmuch as in many Bodies there are found but one of these *Pyramidal* Muscles, and not always just two; since one that is big enough can answer the aforesaid Uses: Nor yet are the same necessary, when the ascending and descending oblique Muscles are of equal Strength, as has been sometimes observed.

SECT. XVI. *The Use of the Right Muscles.*

BUT besides all this, there seems still to remain the following Inconveniency; that the Belly being contracted by these Muscles with so great Force only sideways, the Intestines would hereby be pressed as much upwards as downwards, and would likewise be driven with too great Violence upwards against the Midriff; so that the flexible Structure of the Cartilages would be raised upwards, by which Means the Protrusive Faculty would be weaken'd. To prevent which, and that nothing should be deficient in this great Work, the Wisdom of the Sovereign Creator seems to have fasten'd two other Muscles *QQQ*, called the *Right*, to the *Os Pubis* at *S*, after such a manner, that their other Extremities *Y Y*, should be fastened to and about the Breast-bone; whereby these being contracted, or made shorter in their Fibres, draw the Ribs, with their Cartilages (which terminate in the Breast-bone) downwards; and so they do not only hold fast to the Places to which the Midriff is fixt, but likewise hinder the same from bending upwards by the strong Pressure of the Bowels against the Midriff, when those Bowels are thrust upwards and downwards by the aforesaid annular Muscles of the Belly.

There are likewise seen in the Right Muscles *QQQ*, three or four *Lateral white Fibres R R R*; which

which do most commonly divide each Right Muscle into four other, following one another, to the End, that these Muscles may perform their Function by a lesser Contraction, and proportionably by a lesser Tumefaction, and so not take up too much room; which otherwise, in case the Fleshly Fibres of the *Os Pubis* should extend themselves to the Breast-bone, would not be perform'd so regularly or conveniently.

The other Uses which are ascribed by the Anatomists to these *Right* and *Pyramidal* Muscles, may be seen and consider'd by every one in their Writings; we having dwelt long enough upon them here already.

SECT. XVII. *Orifices in the Muscles for the Seminal Vessels.*

HE that is not satisfied, that all these things are performed for wise Purposes, let him cast his Eyes farther in *Tab. II. Fig. 1.* upon the Orifices described by the Letter I, as they are found in the three Muscles; thro' which, at the Groin, there goes the Tube W, thro' which the Seminal Vessels in the Males, and the round Ligaments of the Matrix in the Females do pass; and consider whether such necessary things as these are placed there by Chance.

SECT. XVIII. *The Voluntary and Spontaneous Motions of the Intestinum Rectum.*

To add something more to what has been said above, and which seems to me sufficient not only to settle a Sceptical Mind, but even to convince an obstinate Atheist; let both these unhappy Men seriously consider, that in this great Length of the Tube of the Bowels, which is continued from the

Stomach to the *Intestinum Rectum*, no body can increase or diminish the Contractions or Wringings of the same ; insomuch, that all those Motions (whereby that which is in the Bowels is protruded and discharged) are quite out of the Power of his Will ; but if the same should have place likewise in the lowest Part of the *Intestinum Rectum*, Mankind could never have any command over their Natural Evacuations, in order to retain or discharge them, as occasion should require. And can a Man yet doubt, whether there be a God that has wisely and graciously order'd all these things, when he perceives, that in the whole Structure of the Bowels, it is the *Intestinum Rectum* only, into which Nerves are derived from the *Medulla Spinalis*, or Marrow of the Back-bone ; yea, that the Motion of that Bowel alone is subject to our Will, for the Prevention of so many Inconveniencies, which it would otherwise be impossible to avoid !





CONTEMPLATION V.

*Of the Venæ Lactææ, and Ductus Chylicus.*SECT. I. *The Transition.*

AFTER having traced the greatest Part of the Food as low as we could, let us now turn back again to the Stomach, in order to observe the Ways and Passages by which our merciful Preserver has been pleased to conduct the Chyle or Nourishment that is extracted for our Food, in order to prepare and render it more useful for making good what is wasted in our Bodies.

Not to mention in this Place the curious and skilful Structure of the *Gall-Bladder*, and the Vessels, which coming out of that, and of the *Liver*, do continually introduce a great Quantity of *Gall* into the *Duodenum*, where it mixes itself with the Food that is sent thither thro' the *Pylorus* from the Stomach; but more particularly, as often as by the drawing in the Breath, the Midriff descending, presses upon the Liver, and thereby squeezing the Gall-Bladder (which lies within the Liver) forces out the Gall through a Vessel that reaches from its Bladder to the Intestines. To say nothing here of that Liquor that proceeds from the *Pancreas* or Sweetbread (a great Gland lying under the Stomach) which mingles itself with the extruded Gall, about four or five Fingers below the *Pylorus*, or lower Orifice of the Stomach, and mostly by the same Passage.

Not to enter here upon enquiring into the Uses of both these; whether, for instance, they serve together to separate the Chyle from the grosser Parts of the Food; or to preserve the same from Corruption by the Bitterness of the Gall; or to render it more fluid; or to incorporate those Parts of it which cannot otherwise be easily mixed, such as the fat and watry Parts; or to qualify the Bitterness of some by the others; or for any other Purposes, which, by a more nice Enquiry into the Nature of them, are daily discover'd: But seeing that the determinate Use of each of these has not yet been decided, we shall confine ourselves to those things only, from which we can draw such undoubted Conclusions, as are more than sufficient to prove abundantly the Perfections of our Maker: Since that which is still unknown and uncertain, will remain to us a continual Object of Enquiry, and of Astonishment at his Wisdom, which does so vastly exceed our own.

SECT. II. *The Venæ Lactææ and Receptaculum Chyli in a Dog.*

To proceed then: If there were no Lateral Orifices or Openings in the Membranes of the Duod of the Intestines, (as there are none in the Throat, for instance, and Stomach) the Chyle or Juice, which becoming Blood sustains the Body, would be discharged at the same time, together with the grosser Parts that pass thro' them; and Mankind would consume away and die for want of Nourishment. Can it therefore be thought, that this likewise is meerly accidental; that in order to prevent the same, there lies in the Mesentery G G, (*Tab I. Fig. 6.*) besides the Blood Vessels I I, and the Nerves m m m, which pass thro' it, another kind of very narrow Vessels ll, which, when a Creature

Creature has continued long without eating, are quite invisible, but if you dissect them a few Hours after it has been fed, they appear as little Veins full of a white Matter like Milk; from whence it is also, that they take the Name of *Milky Veins*, (*Venæ Lactææ*.) These little Tubes open into the Intestines L L, which by their contracting and protrusive Motions, do squeeze out the thinnest of the Food, or prepared Chyle in these Milky Veins, under the Form of a white Substance; which (in Dogs, according to this Figure borrowed from *Verheyen*) takes its way, first towards a great Gland K; but in Men, by several other smaller Glands; since, according to the said *Verheyen*, this great Gland is not found in them. Those that desire to see the Description of the Mesentery in a Man, may be pleas'd to consult the 18th Table of the said Author, where the Glands are represented by the Letters *a a* in the 2d Fig.

We shall say nothing of these Glands, because Anatomists are not as yet entirely agreed about the Use of them; only 'tis known that this Chyle is discharged into a large Receptacle O, by the *Venæ Lactææ* (*Tab. I. Fig. 6.*) coming from this Gland: The Anatomists call it *Receptaculum Chyli*, or *Cisterna*.

SECT. III. *The Receptacle of the Chyle in Humane Creatures.*

IT must be remembred, that in this Figure the Course of the Vessels is represented as it appeared in Dogs, forasmuch as they are seldom to be shewn in Men, who cannot be so soon open'd after their Death. However, they that desire to see a true Description of these Parts, as they lie in Humane Bodies, may find them in the *Leipsick Transactions*, p. 57. Anno 1699. extracted from an

English Book of W. Cooper, consisting particularly in the following Differences: (1.) That the great Receptacle of the Chyle, represented here by the Letter O, is composed in Men of three large Tubes and Parts. 2. That the Links of the Chains that are here described at S, (in the Tube O s, which runs upwards, and is called the *Ductus Chylicus*, or *Thoracicus*) are observed to be more numerous or various in Men. *Rohault* does likewise make mention of one that is found in a Man.

SECT. IV. *The Course of the Chyle to the Heart.*

TO return: In this Receptacle O, the aforementioned Food mixes itself with another Humour, Water, or Whey, which the Anatomists call the *Lympha*; and which having performed its Service to the Body, is continually derived this Way by the *Vasa Lymphatica*, or Water-Vessels; and then this *Chyle* and *Lympha* pursue their Way together upwards thro' the Belly and Breast along the Back-Bone, from the Receptacle of the Chyle O, thro' the *Ductus Chyliferus rr*; and finally are discharged at *u*, in the *Vena subclavia ux*.

The Blood running from *u* to *x* in the said *Subclavia*, goes from thence thro' *x B*, called the *Vena Cava*, or Hollow Vein, to the Heart A; from whence the *Chyle* and *Lympha* being mingled with the Blood in *u*, are carried round with its Stream throughout the whole Body, in order to the Nourishment thereof.

Now can any one suppose, that the Structure and Disposition of so many Vessels, such as the *Vena Laetea ll*, the *Receptaculum Chyli O*, and its *Ductus rr*, are produced by Chance? Can it be without Design, that the *Vasa Lymphatica qq* and *tt*, do discharge themselves in the two last mention'd Receptacles and Ducts, to make a perpetual Stream, in
order

order to convey the Chyle with greater Convenience to the Blood in the Vein *u x*? Of all which, if any thing fails, or is deficient, a Man runs the Risque of losing his precious Life. Is it without Wisdom that the Creator is pleased to divide the Receptacle of the Chyle *O*, into three Tubes in Men, which in Dogs and other Creatures is but one large one? To the end, that in Men, who walk erect, the great Quantity of the Liquor should not easily burst the Membrane that composes the Receptacle *O*, and which is unconceivably thin and fine.

If all this be not yet sufficient to convince any one, let him attend to that which follows concerning the *Valves*, which will lead him as it were by the Hand to an Almighty and All-wise Creator.

SECT. V. *The Valves in the Ductus Chyliferus, Venæ Lactææ, and Vasa Lymphatica.*

CAN we not again visibly observe a fix'd Purpose and Design of bringing the Chyle to the Blood and Heart? Which otherwise, together with the *Lympha* in the *Ductus Chyliferus rr*, (*Tab. I. Fig. 6.*) ought naturally to descend, by reason of the erect Posture of Men: To prevent which, it is most wonderfully provided by the Great Creator, that there should be *Valves* in the said Tube or *Ductus*, which are opened by the Chyle when it proceeds upwards from *O* to *u*, and so takes its right Course, but are shut by the same, if it should attempt to go backwards and descend; just as we see in the Gates of Sluices, which, as the Water comes one Way, are open'd without Trouble, but shut of themselves on the other Side, by the Flux of Water against them.

And there being a Danger that the Liquor in the *Vena Lactea ll*, and in the *Lymphatica qq*, should descend and go backwards by its own Weight, the like kind of Sluices or Flood-gates are placed in both of 'em.

Among the Lymphatic Vessels, the *Ductus Chyliferus* itself *rr*, must be reckoned, since it is likewise continually full of this Water, or *Lympha*, when there is no Chyle mingled with it; and since, as we have said before, it has also its Valves, the Figure of which may be seen in some measure in *Tab. II. Fig. 2.* at *cc* and *cc*, and which are in like manner opened by the Liquor that runs from *a* to *d*: But if the same Liquor should run backwards from *d* to *a*, they would be closed thereby.

SECT. VI. *The Protrusion of the Chyle.*

NOW if it be further observed, that this Vessel is exceeding tender, for which reason it is likewise guarded by the *Pleura*, or Membrane of the Ribs; that it has no sufficient Fibres for protruding the Liquor contained in it when necessary (which Fibres do for this purpose abound in the Intestines and Arteries) but that nevertheless the Process of this Liquor is so necessary towards the Preservation of our Lives, that they could not continue without it; ought we not again to stand amazed at the Wisdom of the great Creator, who in this case has been pleased to use a singular Method to drive this Liquor upwards, causing for that Purpose the great Artery *C*, (*Tab. I. Fig. 6.*) to run along the same; placing the *Intercostalis ccc*, as also the Artery of the Reins *D*, above and across the same, which swelling at every Pulse of the intruded Blood, do as often press upon this Tube; and the Liquor thereof being hindered by the Valves from going back-

backwards, must necessarily move forwards and upwards; to which likewise the Tendons of the Midriff, which are drawn up in breathing, and which also press upon this Tube, do seem very much to contribute?

Is it not now very plain, the Motion being performed after this manner, how necessary these Valves are, since without 'em the Pressure might as well force the Liquor downwards as upwards? It does likewise appear, why they are placed so close to each other, and are more numerous here than in the Veins, *viz.* that the Liquor should be immediately stopp'd as it endeavours to return; whereas otherwise, if the Tube between the two Valves should be very long, it might cause it to swell so much, by reason of its Tenderness and Length, that there would be not only a Danger of bursting, but the Motion or Course of the Liquor would likewise become too slow.

SECT. VII. *The Valve in the Vena Subclavia.*

HERE is yet another Instance of the wonderful Wisdom of Divine Providence, tho' it seems to be but a small matter; namely, that this *Ductus Chyliferus rr*, discharging its Liquor at *u*, into the Subclavian Vein *x*, is covered at its Orifice with a little membranous Valve in the Shape of a Half-Moon; which does hinder, in the first place, the Blood from descending from the Vein *u x* into this *Ductus Thoracicus rr*, and secondly, is the Cause that this little Membrane, being only open exactly on the Side *x*, the Way that the Blood runs, the Chyle coming out of it is thereby immediately carried along with the Stream thereof; whereas, if it had been open on the other Side, the Blood by its strong Circulation would press into this Vessel *rr*, and so hindering the Chyle
from

fully and wonderfully made ; marvellous are thy Works, and that my Soul knoweth right well.

The Manner in which the *Psalmist* here expresses himself, has often seemed to me merely hyperbolical ; for if we contemplate the Human Body in its external and visible Structure, as to its *Strong Muscles, Hard Bones, Solid Intestines, Tough Tendons, Ligaments, Membranes, &c.* it does not appear to be so *fearfully* made, beyond other natural Things : But having more seriously reflected upon the abovementioned Matters, and others of which we shall treat hereafter, and weighing their Usefulness towards the Preservation of our Lives, which is much greater in these than in most of the other solid Parts that were known to the Antients, this strong Expression did not appear to me a jot greater than the thing itself really deserv'd, and convinced me moreover of the Divinity of the Text, so emphatically treating of those things which have been but lately found out by our learned Anatomists, and consequently that they must be known to him that indited it, tho' concealed from all the World besides.

Let it not therefore be thought strange, that the *Holy Ghost* does here so peremptorily ascribe the Praise to God alone in this Case ; since no *second Causes*, nor any human Skill, or Art, has in the least concurred towards the Support or Preservation of such tender Parts in their proper State and Condition.

Every one knows how necessary all this is, not by remote Consequences, but in itself, towards the Life of Men or Beasts. And what Physician is there in the whole World, whose Knowledge can penetrate so far, as to inform us of the smallest Signs and Tokens of the Disfrangement of these Parts ? I never saw nor read of any Surgeon

geon that pretended to re-establish any of them, when disordered or displaced; or to go yet further, that ever will be able to find out any thing fit for that Purpose. If but one single Valve of the *Ductus Chyliferi* were obstructed, and could not open itself (which would cause our Bodies to waste away) what Writer has, or can suggest any rational Method of curing such a Distemper? Are we not then *fearfully*, yea, exceeding *fearfully made*, when the most tender and nicest Parts can be the most easily disorder'd, and when once it so happens, can never be put into their proper Situation again, but will occasion unavoidable Death: Add to this, That we can never discover the Danger of such Disorder, so as to be able to obviate the same in any manner.

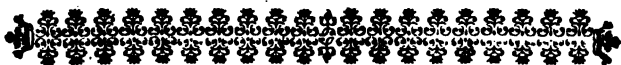
May we not be said to be *wonderfully made*, when (to say nothing of so many Particulars, of which mention is made elsewhere) we find that such small, weak, and tender Instruments, as are these *Valves*, are able to perform their Functions for the Space of 60, 70, or 80 Years together, without being worn out, or spoil'd? Whereas no body that knew their delicate Structure, unless he found it experimentally true, in the Bodies of old Men, would dare to maintain that they could continue in the Discharge of their Office, without any Disorder, hardly so many Months.

How often do Clocks, Mills, and other moving Machines stand in need of being adjusted by a skilful Master? And ought not this to teach every one, that a great Director does support and maintain all these things in that necessary State, towards which all Creatures, all the most skilful Physicians, all the most learned Philosophers, or the most ingenious Artificers, cannot contribute the least in the World? And how can any Man forbear charging himself with the utmost Unreasonableness,

sonableness, who seeing so great and important a Work, as is the Life of Men and all other Creatures, carried on by so simple; and, in appearance, contemptible Means, does nevertheless persist in ascribing it all to meer Chance, or ignorant Causes! And being sensible how much Good is thereby daily produced in himself (concerning which he is forced to own, that he not only gave no Direction, but, which is more, that he had not the least Perception;) must he not pronounce himself both ungrateful and worthy of Condemnation, as often as he refuses to acknowledge the Mercy and Goodness of his Benefactor, and even his Wisdom also, in the midst of so many Wonders?



C O N-



CONTEMPLATION VI.

*Of the Heart.*SECT. I. *The General Use of the Heart.*

LET us now go on, and trace the Chyle or Food (which, as we have just now shew'd, is mingled with the Blood at the left Subclavian) quite to the Heart; in the Structure of which there do occur so many wonderful Things, that one would imagine that none but a very unhappy or obstinate Person, seeing and comprehending the Composition of this Organ, could help being convinced of the Wisdom of the Great Creator, and of the determinate End to which it is adapted, *viz.* the Reception and Expulsion of the Blood, (whether there be other Uses of the Heart, I shall not here enquire) to the end, that the Blood by this Motion, having perfected its Circulation thro' the Lungs, and thro' other Vessels, to all the Parts of the Body, and performed several other Functions in other Places, might return to the Beginning of its Course, that is, to the Heart and Lungs.

SECT. II. *The Description of the Heart.*

THE Heart has two Cavities, or Ventricles, separated from each other by a thick fleshy Wall, or *Septum*, which every one may see, that will take the trouble to cut across the Heart of an Ox or Sheep.

The

The Heart, at the upper part of it A, (Tab. II. Fig. 3.) is thick, but at the lower part B, much slenderer; the Shape of it is like that of an inverted blunt Pyramid; it is fastened, and hangs by its Veins and Arteries E F G H I; E is the *Vena Cava*, or hollow Vein by which the Blood descends; G is the *Vena Arteriosa*, or *Arteria Pulmonaria*, (the Pulmonic Artery) thro' which it passes out of this Ventricle into the Lungs; and H is the *Arteria Venosa*, or *Vena Pulmonaria* (the Pulmonic Vein) thro' which the same Blood returns from the Lungs into the left Ventricle of the Heart; out of which it is carried by the *Aorta*, or great Artery I, to all the Parts of the Body; C is the Right Auricle of the Heart, into which the Blood passes from E and F, before it falls into the Right Ventricle; D is the Left Auricle, which performs the same Function to the Left Ventricle; K K are the *Arteriae Coronariae*, and the *Vena Coronaria*, which feed the Heart, and provide it with Blood.

SECT. III. *The Eminence or Protuberance in the Vena Cava.*

BUT here the Stream of Blood descending from the *Vena Cava* at E, meeting with another Stream ascending at F, seems to threaten the apparent Danger of these two Currents rushing against each other, either within the Ventricle or Auricle of the Heart; for that Blood which comes down from E, assisted with its own Weight, and having therefore a greater Strength, might hinder the other, which coming up from F runs against it, from pursuing its Course; and so the Circulation of the Blood, and therewith the Life itself, might soon come to an End.

Now

Now to prevent these Inconveniencies, that would otherwise be so dangerous, we find that between these two Veins E and F, (both which are represented at A A, *Tab. II. Fig 4.* where they are laid open) there is a Protuberance B, composed of the Fat that lies under, against which the Blood descending from E, runs or strikes, and by that means the Course of it is turned to the Right Auricle of the Heart; whilst the Blood ascending from F, is by the said Protuberance B covered and secured against the opposite Course of the descending Blood, and so is obliged to turn its Course aside to the Ventricle of the Heart.

We must likewise here observe, that this Protuberance B is much greater in a Man (because in consequence of his erect Posture, the upper Blood at E descends exactly perpendicular) that it is in Dogs, Horses, Cattle, and the like Creatures, in which the Course of the Blood at E F is only Horizontal, and therefore does not move with so great Force.

Once again: How very *wonderfully* are we made! And can any body see, without terrible Emotions, that as our precious Life in the *Ductus Chyliferus*, does entirely depend upon such slender and minute Valves, so it does here upon such a small Protuberance as is described at B? If here were no express Design of the adorable Creator, why do we find it just in this Place? Why is it bigger in a Man, where there is a Necessity in Nature for its being so, to balance the Force of the descending Blood; and less in such Creatures where such Balance is not wanting to perform the same Service?

SECT. IV. *The Auricles of the Heart.*

FURTHERMORE, the Course of the Blood, which continually passes thro' these Veins A A, seems to require, besides the Heart, another Resting-place to be contained in, during the Time in which the Heart contracts itself in order to discharge the Blood, and while the Valves of the Orifice of the Right Ventricle are shut; to the end that it might be there collected in the mean time, and as soon as the little Valves are again open, be swiftly emptied into the Heart; for which Purpose the Auricle C, (*Tab. II. Fig. 3.*) serves on the right Side of the Heart, as D does on the left, which whilst the Passage thro' the Valves is stopt, are full of the Blood that runs into them, and are provided, after a wonderful Manner, with Muscles and other Instruments, by which means each of them can swiftly contract itself as there is Occasion, and lose no time in the sudden Discharge of the Blood into the right and left Ventricles of the Heart.

SECT. V. *The Operation of the Heart.*

THE Blood being now come thither at the time when the Heart does as it were loosen and open itself (I do not here dispute whether there be a Faculty in the Heart required for that Purpose) it contracts itself suddenly, and with great Force; insomuch, that the sides of the Right Ventricle approaching each other by such a Contraction, and the upper and lower Ends thereof being likewise drawn together, the whole Cavity is in a manner closed, and the Blood thereupon driven out with great Swiftnes into the Lungs thro' the Pulmonic Artery, or *Vena Arteriosa* G, (*Tab. II.*

F.

Fig. 3.) and goes onward thro' the Pulmonic Vein, or *Arteria Venosa H*, to the Left Ventricle of the Heart, after it has been distributed thro' the Lungs.

One may have a gross Conception of this Working of the Heart, by comparing it to a Bellows full of Water, in which there are two round Holes at Top; the one of which, upon the Closing or Contraction of the Bellows, is stopt with a Valve, whilst the other remains open; now, in case you should with a sudden and violent Motion press the Sides thereof together, so that in a Moment, or in the time of one Pulse, the whole Cavity thereof were taken away, it can scarce be imagined with how great Swiftnes the Water in the Bellows would spring out of the Orifice which remains open: And this is a rough Idea of the Manner in which the Blood is suddenly extruded from the Right Ventricle of the Heart into the Lungs.

SECT. VI. *The Course of the Muscular Fibres.*

NOW in order to perform this so sudden and violent Contraction, or *Systole* of the Heart, the Muscular Fibres of which it is composed, are so wonderfully and so peculiarly adapted to this very End, that he who is not wilfully Blind, and under a deplorable Hardness, must herein necessarily discover the Hand of a Wise and Designing Creator. That this is not said without good Grounds, will appear plainly enough to such as please carefully to consider the Course of these Fibres.

For you may see first, the Fibres, A and B, (Tab. II. Fig. 5.) running obliquely from Top to Bottom, and others described by C and D, crossing the former; both these oblique Fibres being contracted in their Operation, the Cavities of the Heart must

become narrower, and both its Ends in some sort likewise drawn together. Besides these, there are other Fibres that lie above them, and run streight upwards, (*Tab. II. Fig. 6.*) which only belong to the Right Ventricle, and by contracting themselves, do shorten the same. But the Course of the Fibres, that perform the same Work in the left Ventricle, is wonderfully surprising; for those A B, (*Tab. II. Fig. 7.*) running on all sides from Top to Bottom, encompass the Heart at the Point C, and being contracted, draw the same upwards towards A: These Fibres are represented upon the said Point or sharp End, as you may see *Tab. II. Fig. 8.*

Now, in order to assist the lateral Contraction of the oblique Fibres; we may observe a row of other Fibres, A C B, (*Tab. II. Fig. 9.*) running under the oblique ones, which perform their Function, by encompassing the Heart cross-wise, and contracting the same; so that here is in a manner the like Disproportion of Muscles as has been shewn above, in describing those of the Belly: This whole Matter is largely treated of in that little, but accurate Discourse of the Learned Dr. *Lower.*

Let any Body now that understands these Things, seriously consider with himself, whether it be possible, that such a variety of Rows of Fibres, endowed with such a great Strength together (as has been demonstrated by *Borelli*) and all serving to that very Purpose for which the Heart seems alone to have been form'd; that is to say, by its Contraction, to protrude the Blood it has received into the Arteries joyn'd to it; I say, whether all those Fibres can have acquired this wonderful Disposition, without Wisdom and without Design?

Now, since there are not hitherto any other Muscles discover'd in the whole Heart, save those that contract it, and render its Cavities narrower; is this likewise by Chance, that the Fibres thereof
when

when once contracted, are not suffer'd to continue in the same Condition, but presently dilating themselves, do open the Cavities, that they may again receive the following Blood out of the Veins, and by the repeated Contraction of the Heart, distribute it to the Lungs and other Parts continually, and as long as our Lives do last?

SECT. VII. *The Action of the Valves of the Veins.*

THERE still remains another Difficulty in the Use of the Heart, *viz.* that (since each Ventricle has two Orifices, one by which the Blood enters, and the other, by which it goes out again) it seems to be a Consequence thereof, that the Heart being so suddenly and strongly contracted, the Blood should flow at once out of both of 'em, and so be forced backwards by the same Passage by which it enter'd into this Ventricle.

To prevent the same, the wise Power of the wonderful Creator does again appear, who for this Purpose has been pleased to place there another sort of Valves (which, by reason of their Triangular Figure, the Anatomists call *Mytrales*, because they represent a Bishop's Mitre) in that part of both the Veins, thro' which the Blood is discharged into the Heart; and these, when the Heart contracts itself, and the Blood is thereby driven towards the Orifice, in the Circumference whereof they are placed, are thereby shut very closely: These Valves (which we can hardly look upon without Amazement, if we consider the Providential Views of the Creator) are fasten'd to the Sides of the Ventricles with a great many tendinous Fibres, that are very strong, in order to secure the Valves when they are shut, like so many Bars and Chains upon Doors, to the end that the Force wherewith the Blood that was squeezed out of the

Ventricles acting against them, may not break them open, or bend them in such Manner on the other side, as to mak a Passage thro' them for the Blood; especially, considering that they are composed only of thin and flexible Membranes, and not of Bones or other solid Matter.

These Tendinous Fibres, have moreover the following remarkable Uses: *First*, That as the Heart after its Contraction, does again dilate. it self and become longer, and consequently the Sides of it, which were raised upwards, do sink down again; I say, the said Fibres being fasten'd to the Sides, draw the Valves open (as is done in the Gates of some Sluices with Ropes) in order to make a free Passage for the returning Blood. *Secondly*, That these Fibres are fastened in such a manner to some little Protuberances, or Pits of the Sides of the Heart, and even to the opposite Side also, that they can hinder those Valves from falling down flat, or from touching the Sides of the Heart, to the end that the Blood, in the Contraction of the Ventricle, may press against these Valves continually from below, and so raise them upwards, in order to close their Orifices.

SECT. VIII. *Conclusions from the Foregoing Observations.*

I HAVE given an Account of the chiefest of these Matters by Words only, without adding any Figures to them; having found in the most accurate Books of Anatomy, that the best and most exact Figures taken from the Original, are not capable of giving much Light, by reason of the vast Number of Particulars that are observable therein, to such as have not viewed the same in the Heart of any Creature; for they would require more Study and Application to be understood,

flood, than even the Structure of the Heart itself. They that would make a Tryal thereof, may consult the *Fourth Figure* in the *14th Table* of Monsieur *Verheyen*, and the *First Figure* in the *5th Table* of *Dr. Lower*.

Farther, if there were any known Machine to be met with, the Operations whereof had any Analogy or Similitude with those of the Heart, the Description of it might, perhaps, render this Account a little clearer; but neither Pumps, nor any kinds of Spouts, no, not even the modern Engines for quenching Fires (tho' in the opening or shutting of their Valves, they may seem in some manner to imitate the Heart) nor any thing else that Art has yet been able to produce, can any-wise come near them, to represent the great Wisdom wherewith this wonderful Machine of the Heart is formed. Can any Man then imagine, that this great Work has been made by Chance; when no Body dares affirm the same, even of all those other imperfect Machines that have been mention'd above?

Having oftentimes meditated upon these Things, I have thought with myself, *how fearfully and wonderfully we were made*, as upon two other occasions has been mention'd before; for in case one of these Valves should be out of order, and unfit to perform its Function; yea, if one of these little Fibres, which are fasten'd to the Valve, and draw it up, should break, or be either too short or too long, these little Sluice-Gates could not be shut, as not being able to come upon each other, if the Fibres were too short; or if too long, not able to remain so, but forced to give way to the Pressure of the Blood; insomuch, that not only upon each of these little Valves, but, which is yet more amazing, upon the various Length of these fine Fibres, the Life of so Artful a Machine as every Man is;

yea, even the Lives of Kings and Princes themselves, and of all Creatures whatsoever, do entirely depend.

SECT. IX. *The Valves of the Arteries.*

THIS being said of the Orifices, thro' which the Blood passes into both the Ventricles of the Heart, there was yet danger, that when the Blood was protruded from the Right Ventricle into the Artery of the Lungs, and out of the Left into the great Artery, the Heart opening itself again, and the Expulsive Force ceasing with the *Systole*, the Blood by its Weight might go back into the Ventricle of the Heart from whence it came, and so by obstructing the Circulation, cause immediate Death.

But here the Care of a most merciful Creator has interposed, by placing other Valves again at the Beginning of both these Arteries, which perform just the contrary Function to the foregoing; so, that as the former were shut by the Blood that endeavour'd to ascend from the Heart, these are shut by that which descended to the Heart: And, whereas the first were open'd by the Blood that ran to them, the same is effected in these, by the Blood that issues out.

That this may be more clearly conceived, let (*Tab. II. Fig. 10.*) *aa* represent the open'd Part of the Left Ventricle of the Heart; *c* the great Artery dissected lengthwise; *bbb*, the three Semi-lunar Valves, which are shut by the returning Blood; Here they appear lying flat and extended, whereas, otherwise they fill the round Orifices of the Artery; *ff* are the three Triangular, or Mitral Valves turned aside, that you may see the other *bbb*, the better; and at those *ff*, one may observe the Fibres *fg* still hanging, the Ends of which, *gg*, are

are shewn cut off from the sides of the Heart, to which they are otherwise fasten'd, when in their natural State.

How these little Valves *bbb*, are disposed by the Blood that is driven back, and how they shut the Artery, may be observ'd *ccc* (*Tab. II. Fig. 2.*) The Appearance is likewise the same, if you blow into the Artery *A*; *BB* are the Crown-Arteries (*Arteriae Coronariae*) which feed the Heart, and carry their Blood thither; the Openings of which into the *Aorta*, or great Artery, are represented in (*Tab. II. Fig. 10.*) *dd*, exactly above these Valves.

SECT. X. *The Lateral Muscles of the Heart.*

ALL the admirable Curiosities observable in the Heart, would be too many to be here nicely examined into. The Lateral Muscles in the Right Ventricle of the Heart (to pass by a great many other wonderful Contrivances in that Organ) seem here to require more particularly an immediate Attention; these Muscles, holding the Sides of the Heart together, hinder it from being too much extended by the Blood that falls into it at each Diastole, and so serve for a Measure of the Quantity that is to be poured into it at each time; they do likewise contribute to the bringing the Sides nearer together in the *Systole* or Contraction of the Heart. Thus we likewise perceive, that the left Ventricle is encompassed with much stronger Muscles and Walls than the Right, which appears when you cut the Heart a-cross; because that this last is only to convey the Blood thro' the Lungs, which bears no Comparison with the Distance (*viz.* the extreme Parts of the Body) which it arrives at by the Force of the Left Ventricle of the Heart. Whether this Force be wholly determin'd by the contracting

tracting Muscles of the Left Ventricle; or whether the Arteries afford any co-operating Power towards this Motion of the Blood, is yet a Matter in Dispute: But this is certain, that whatever Force conveys the Blood to the Extremities of the Body, contributes towards furnishing it there with the means of returning to the Heart by the Veins. If People cannot here discover the Views and Designs of their Great Creator, their Blindness is much to be lamented: Yea, ought not every one to stand amazed, that sees so much Swiftness communicated to the Blood, by such a soft fleshy Instrument, in order to perform so great a Circulation in so short a time?

SECT. XI. *The Force and Power of the Heart, represented by Comparisons.*

HE that doubts whether the Systole of the Heart is a Force sufficient of itself to bring about such a Circulation, may, without Mathematicks, observe how great a Force and Swiftness is performed by the Compression of two Bodies, by taking a Cherry-stone, and suddenly squeezing it between his Fore-finger and Thumb, which will cause it to fly out more swiftly than a Person never making that Observation cou'd easily imagine: By taking a Handful of wet Clay, and compressing it suddenly, as the Heart does the Blood, another notable Instance offers itself; for, by observing how nimbly the Clay bursts out wherever there is a Passage for it between the Fingers; and, considering at the same time, that this Clay has five Places to come out at (three between the Fingers, one at the Top, and another at the Bottom of the Hand) this Conclusion (which illustrates the Motion of the Blood from the Heart) naturally results; *viz.* that if the Clay issued out
only

only thro' one Passage (instead of five) the Velocity wou'd be five times greater. After the same manner the Spittle which is produced in the Mouth by smoaking Tobacco, is discharg'd with great Swiftneſs: This is perform'd by collecting the Moſture into a Cavity between the Tongue and Lips, which Cavity they afterwards deſtroy, by thruſting the Tongue againſt the Lips, and ſo force the Spittle out. One might inſtance in other Caſes, but this is ſufficient to repreſent, in ſome ſort, the Purpoſe in hand.

SECT. XII. *The Pericardium, or little Bag of the Heart.*

ADD to all this, that the Heart is preſerved in a membranous Bag called the *Pericardium*; which, by furniſhing a Liquor from its little Glands (concerning this, ſee *Bergeus, Malpighius, &c.*) does continually keep the Heart ſmooth, and fit to perform its conſtant powerful Motions, hindring its external Membrane from being wrinkled by too much Dryneſs; and it lubricates and moiſtens the adjacent Muſcular Fibres, by which means this wonderful Inſtrument is enabled to perform its neceſſary Functions, which otherwiſe would be obſtructed.

SECT. XIII. *Conviſions from the foregoing Obſervations.*

To ſay no more; after the Contemplation of this Heart in all its above-mentioned Circumſtances, can an unhappy Philoſopher, even the moſt ill-natured and obdurate Atheiſt, be eaſy in maintaining, that all this is performed without Wiſdom, without Deſign, and only by ignorant Cauſes? Since he cannot but know, that he would be taken
by

by all Men, and without doubt by himself too, for a very foolish Person, in case he durst affirm, that a Fire-Engine only (which by no means is to be compared with the wise Contrivance and Structure of the Heart) was produced by Chance, and without the Concurrence of a skilful Workman. Let him also add, that this Machine is made and put into Motion by another, so that the whole is performed in his own Body, not only without his Will, but even without his Knowledge and Perception; and will he not yet see that his dear and precious Life is preserved by another, who has shewn so great Wisdom therein! How can any one conceive, that this Motion of the Heart, according to the Calculation of the famous Mathematician *Borelli*, must be performed by the exerting of more Force at every Pulse than is required to surmount the Resistance of some thousand Pounds Weight? That such a Motion is performed above two thousand times in an Hour, without ever ceasing, whether we wake or sleep, for the Space of fifty, sixty, or seventy Years perhaps? And particularly since our other Muscles, after much less Pains, and sometimes but in one Day, become so tired and impotent, which never happens to the Muscles of this little Heart in so many Years. And cannot then so great a Matter, brought about by such wonderful Instruments, and after so amazing a manner, convince every Man that is reasonable, and make him conclude with Certainty, that a Power far exceeding Humane Knowledge is here exerted.

Yea none can deny, that according to what we have just now shewn, that as often as he lays his Hand upon his Breast, and feels his Heart beat, that this Motion is performed without his own Concurrence, and consequently by that of another.

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And since we have seen besides, by the foregoing Structure of the Heart and other parts, that this great Creator and Mover of all things is wise, and that our Lives do entirely depend on these Motions produced by his Power: I say, when all this is well consider'd, must not such a Man tremble, who does not only refuse to testify his Gratitude to this mighty, wise, and powerful Preserver of his Life, but also dares openly blaspheme him, and denies all his Attributes and Perfections?



CONTEMPLATION VII.

Of Respiration.

SECT. I. *The Air is necessary to the Blood.*

THOSE who have read the preceding Discourses are already informed, that the Blood discharges itself from the Veins E and F, (*Tab. II. Fig. 3.*) into the Right Ventricle of the Heart; from thence it is introduced into the Lungs (by the Systole of the Right Ventricle) thro' the *Vena Arteriosa*, or Pulmonic Artery G; and from the Lungs it is again discharged into the Left Ventricle of the Heart, by the *Arteria Venosa*, or Pulmonic Vein H.

Now whether the Blood passes from one of these Tubes into the other immediately, or whether it passes thro' that Substance of the Lungs which is of the Nature of Bellows, we will not here enquire; this is certain, that the Air suck'd
into

into the Lungs where this Blood is, does; as long as Life lasts, come in and go out again; and whatever the Use of it be, it is so great, that no Man can want it a short Space of Time, without presently dying; and it is no less probable, that the Instruments by which the Air is conveyed into the Lungs, are made with great Skill and Contrivance.

SECT. II. *The Blood-Vessels and Aspera Arteria in the Lungs.*

HE that doubts of this, let him take the Lungs and Wind-pipe of a Lamb, or any other Animal, in which may be observed, 1. That the upper Orifice of the said Wind-pipe can be covered with a small Cartilage, called the *Epiglottis*, whilst the Food is descending thro' the Gullet that lies behind it, into the Stomach. 2. That whereas the Branches of the Wind-pipe, which spread themselves into the Lungs, are Cartilaginous, and of a Round or Cylindric Figure, that they may always remain open; yet the Wind-pipe itself, where it lies upon the Gullet, that it may not hinder the Passage of the Air in the fore-part of it, does by its Cartilages compose part of a circular Figure only, and behind has only a membranous Covering, because the Cartilages perceivable in the fore-part of the Wind-pipe, would press too hard upon the Gullet, thereby incommoding the Passage of the Food. 3. The wonderful Structure of the Air-Tubes, or Branches of the Wind-pipe, (*Tab. II. Fig. 12. A E*) which passing throughout the Lungs, lie between the two Blood-Vessels *B E* and *C E*; of which *B E* serves for a Passage to the Blood that enters into the Lungs, and *C E* to that which coming out of the same enters into the left Cavity of the Heart. The same is observed

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Fig.



Fig.



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served to happen constantly in these Lateral Branches; the Blood-Vessels being cut off here, they are represented finer, and the Ramifications of Air-Vessels interwoven with them, are more commodiously described.

SECT. III. *The Glands in the Wind-pipe.*

BUT if it was necessary to use great Care in the Formation of any Part of the Body, it seems to be mostly so here, to the end that this Tube, (which as long as we live, or whether we wake or sleep, admits of a constant Influx and Reflux of Air) should not by this Air grow dry. Is there then no Design to be traced and observed here? Since the Omniscent Creator has clothed the same on the inside not only with a Glandulous Membrane, from which a Humour is always filtrating, and in order to moisten the Throat itself, has been pleased to place two Glands called the *Thyroidea*, of a considerable Bigness; for that Use, besides those other Glands which we commonly name the *Almonds*, but further, to manifest his intended Purpose more clearly, has planted in all those Places where the Air-Vessel is divided into Branches, very visible Glands for the Moisture thereof; (whether they have any other Uses besides, we are not now enquiring :) And forasmuch as the *Epiglottis*, by reason of the continual passing and repassing of the Air that strikes upon it, seems almost impossible to be kept moistened, and if it were dry, could not so well discharge its important Function; can any one see, without Astonishment, how the great and wise Contriver thereof, has furnished this Cartilage with so many little Glands above and below, in order to moisten it beyond all others!

SECT. IV. *A Hundred Muscles requisite towards Respiration.*

NOR to mention here the Divisions of the Wind-pipe into so many Cartilaginous Rings, nor the Membranes and Fibres by which they are fastened to each other, nor the wonderful Structure of the *Larynx*, consisting of so many Cartilages, and moved by fourteen Muscles, to the end that by all this *Apparatus*, the Wind-pipe and its Orifice being several ways lengthened and shortened, dilated and contracted, the Voice might be thereby formed, and yield a more shrill or deep Sound; which things being now become the Object of the Enquiry of several great Naturalists, we shall here confine ourselves only to Respiration; and content ourselves with asking any one that does still question the Wisdom of his Creator, whether he can believe that the Instruments, which, besides the Lungs, are necessary thereto, could be ranged and placed near the others without any Understanding or Design? Especially if it should be proved to him, that altho' the Midriff alone is sufficient for Respiration, yet to the end that so necessary a Work as this is, might not easily be obstructed, about a hundred different Muscles are likewise applied to the same Purpose; and, as easy as the Action of breathing may appear to be, that in a strong Respiration (when every one of this great Number of Muscles, that are capable of being used therein, are employed for the Purpose) before the Breath be drawn in and driven out again, this great Number of Muscles must have all been employed for that Purpose.

This is sufficiently known to the Anatomists; and, to give you a small Sketch of it here, we shall inform you, that in drawing in the Breath, in
order

order to raise up the Ribs and the Breast-Bone, and thereby to dilate the Cavity of the *Thorax*, or Breast, there are put in Motion on the one Side, one *Musculus Subclavius*, eleven *Intercostales Externi*, eleven *Levatores Costarum*, besides the *Serratus Anticus Minor*, the *Serratus Anticus Major*, the *Serratus Posticus Superior*, and the *Cervicalis descendens Diemerbroeckii*, and three others which are therefore called *Common*, because they likewise perform other Motions, viz. the *Pectoralis*, *Scalenus*, and *Levator Scapulae*, which together make thirty Muscles on one Side; and there being as many more on the other, are in the whole sixty that are employed in *Inspiration*, or drawing our Breath inwards.

Towards *Expiration* there are likewise employed nineteen Muscles on a Side, eleven *Intercostales Interni*, the *Triangularis*, the *Sacrolumbus*, and the *Serratus Posticus Inferior*, and with these also five *Common* ones, viz. the Muscles of the Belly; these are altogether thirty eight Muscles, used for *Expiration* only, which being added to the sixty above, make together the Number of ninety-eight: Now if you add to these the Midriff, being the principal Instrument of them all, and which, according to the Opinion of that great Anatomist *Verheyen*, consists of two, or it may be three Muscles more, there must, according to this Computation, be at least a hundred Muscles made use of in one single Action of Breathing as strongly as we can. These Observations we find made in the *Acta Lipsiensia*, Anno 1707, of *J. G. Pauli*, upon *Van Horne*.

I would now ask again, whether any Body can suppose that such a Disposition, where there are so many Muscles consisting of Fibres extended so many different Ways, is produced by Chance, or without Design? Or whether it does not plainly appear to him, that this great Composition of

the Muscles is expressly adapted to the end of Breathing.

SECT. V. *Without Air this whole Structure is useless.*

BUT if what has been here mentioned concerning the Disposition of these Muscles, shall appear wonderful in every Man's Eyes, will he not yet stand more amazed at the Wisdom of the great Director of all Things, when he finds that all these Instruments, tho' never so artfully adapted to Respiration, would be yet in vain, and of no manner of Use, if Mankind, and all other Creatures breathing, were not surrounded with such a Matter as the Air is, which has in it, among other Properties, an Expansive Power (*Vis Elastica*) besides a Weight, which causes it to operate and dilate itself; from whence it comes to pass, that as soon as the Breast is enlarged by the Operation of the above-mentioned Muscles, this Air immediately rushes into the Wind-Pipe and Lungs; of which Property (taking it at present for granted) we shall treat more largely hereafter, when we enter upon the Contemplation of the *Air* itself; and we shall prove experimentally, that in an Air which is but partially divested of this *Elastic Force*, almost all Creatures will immediately perish.

SECT. VI. *The Properties of Expanded Air.*

HOWEVER, that we may here give you some Idea of Respiration, it will be necessary to represent previously, 1. That when the Place in which any Air is shut up, is made larger, the said Air filling a greater Space, is so much the more weakened in its expansive Force. 2. If the Air thus weakened has any Communication with other Air that is stronger, and both of 'em can act upon each

each other, the stronger Air will immediately rush into the enlarged Place, in which the weaker was contained.

SECT. VII. *The Comparison of Respiration with a Pair of Bellows.*

To prove this by a Comparison, one need only represent to one's self a Pair of Bellows, (*Tab. III. Fig. 1. A E F*) in which we know that nothing more is requisite in order to draw the Air into the Mouth A, or Tube A B, than to separate the Sides E D and F G from each other; by which Means the Space E D G F is enlarged; and so the Air that was contain'd therein being weaken'd, and not powerful enough to ballance the external Air, with which it had a Communication by the Tube A B, the last being now become the strongest, does by its *Elastic Force* crowd itself into the Mouth of the Bellows.

The same thing would happen, if one supposed that a Bladder B C were fastned to the Tube A B within the Bellows; in which Case the Space K being dilated, the Air therein would likewise be too weak to resist the Air which fills the hollow of the Bladder B C, thro' the Tube A B, by which means this Bladder will be blown up, and expanded by the stronger external Air rushing in upon it.

Now if you suppose the Tube A B to be the Wind-Pipe, the Bladder B C the Lungs, and the Space thereof E D G F the Cavity of the *Thorax* or Breast, you will see the Reason why the Air rushes thro' the Wind-Pipe into the Lungs, to which it is fastened like these Bellows, when by pressing down the Midriff, and by the other Muscles, the Breast is made wider and larger.

He that desires farther to see how the Lungs, whilst hanging to the Wind-Pipe, may be puffed up by the Air, need only take the Trouble of blowing strongly into the Wind-Pipe of a Sheep or Ox newly killed, by which means he will see the Lungs, like Bellows, expanded by the Wind that passes into them.

SECT. VIII. *An Experiment upon the Lungs in Vacuo.*

I HAVE represented these Appearances after such a gross manner, to the End that those who have not the Opportunity of using the Air-Pump, may have some Conception thereof; but those that have used this extraordinary Instrument, so necessary in examining the Works of the great Creator, may form to themselves a much clearer and more distinct Notion thereof.

Let the Covering O P be laid upon the Glass O P F, *Tab. III. Fig. 2.* standing upon the Air-Pump, which has a little Tube A N B passing thro' the Centre of it, and a little Cock at N, which now appears open, but may be shut; under this Covering, at the Extremity of the little Tube A N, there is another screwed on at B C, the End of which is stuck into the Wind-Pipe of a little Piece of Lungs D, which is tied fast to it.

Now when the *Piston* or Sucker L M of the Air-Pump is thrust to I K, or so far inwards as possible, one sees that the Piece of Lungs D hangs in the Space E, that does not extend itself farther than from O P to I K, when the Cock G H is open, in which Space the internal Air is shut up; but the little Cock at N being turned, the Sucker is drawn backwards from I K to L M; and then the Space that contained the included Air is so much larger, as the Distance between I K and L M;

L M; both Spaces being filled by the Expansion of the Air, which therefore loses a great deal of its Elasticity: This will appear, if you open again the little Cock **N**, when the external Air rushing into the Piece of Lungs **D**, thro' the Tube **A B**, blows it up; the Reason of which is, that this Air having lost nothing of its Elasticity, presses more strongly into the Lungs **D** from without, than the included Air at **E**, which presses it inwardly, is able to resist, because of the weakning of its Spring.

That this is true, will appear, forasmuch as if you thrust the Sucker **L M** towards to **I K**, and drive the included Air into a narrower Space, it will again strongly expand itself at **E**, and pressing with more Violence the Lungs **D**, will make them become smaller, by forcing the Air which was in them to go out again thro' the Tube **B A**; and this Effect you may produce as often as you repeat the Experiment, by drawing or thrusting the Sucker backwards or forwards. Now if you will suppose the Tube **A B** to be the Wind-Pipe, the Space **O P K I** to be the Cavity of the *Thorax*, and the Sucker **L M** the Midriff, there will be a mighty Analogy between that Experiment and the Business of *Respiration*; and the whole Difference is only, that whereas the Cavity of the *Thorax*, in which the Lungs hang, is dilated and contracted by the Muscles and other Instruments; the same Effect is produced in the Air-Pump, only by the Sucker thereof.

Now such as don't think it worth the while, or have not the Opportunity of making this Experiment with the Lungs of any little Animal, may use an empty Bladder **D**, tying the same to the End of the little Tube **B C**, which will give them all the Appearances very conveniently and agreeably; so that with but half a turn of the

Handle of the Air-Pump one way or other, they may fill or empty the Bladder of Air.

SECT. IX. *An Experiment with a little Bottle of Water.*

Now if any Body has a Mind to see with his own Eyes, after what manner and how violently the Air crowds itself into the Lungs as soon as the Cavity of the Breast is enlarged; instead of a Piece of Lungs or Bladder, let him take a little Glass Viol, holding about an Ounce or such like Quantity of Water, and tye it to the Tube B C, so that the End of the Tube may be thrust as far as it can into the Water, then shut the Cock N, and enlarge the Space as before, by drawing back the Sucker to L M; let him open the little Cock N, and he will see that the External Air, which by its strong expansive Faculty forced itself inwards, will put the Water into a very violent Motion, just as if one should set his Mouth to the other End of the Tube A, and blow thro' the Water as hard as he can.

SECT. X. *The Experiment of a Syringe in Vacuo.*

Now, in order to convince every one experimentally, that altho' a Space be enlarged, as happens in the *Thorax*, when we draw in our Breath, or even, tho' a Space be made where there was none before, as in a Syringe, by drawing up the Sucker; there are nevertheless Cases, in which, if the Matter that otherwise rises up in the Syringe, has no Expansive or Elastical Parts in it, or is not moved or pressed after some other manner; it will by no means run into the empty Spaces, in order to fill the same: Let any one but cast his Eye upon this little Machine, F H I, (*Tab. III. Fig.*

Fig. 3.) which is commonly to be found in the Shops of those that make Air-Pumps, and he will see, that if an empty Space be made in the Syringe A B, by drawing up the Sucker F A, (after having first discharged the Air at G, out of the Glass-Bell A B I, thro' the Air-Pump) the Water in the little Glass D E, in which the Tube of the Syringe stands B C, and which is open at C, will by no means rise up into the Tube, nor fill the empty Space in the Syringe, as usually; because the Water D E, has no sensible Elasticity or Spring in itself, nor is acted upon, by any other Elastick Body, which in this Circumstance would be requisite; from whence one may conclude, and not obscurely neither, what we have already said concerning Respiration, viz. That altho' there be Space enough prepared in the Breast, in order for Breathing, yet, in many Cases no Air (if, like the Water, it should happen not to be Elastick, nor heavy enough) would come in: All which, is yet hereby more evident, that, so soon as one lets in the Air again into the Glass Bell, H I B, the same gravitating upon the Water D E, by its Elastick Force, immediately causes it to rise up into the Space that was made for it at A B, thro' the Tube B C, in which, as there is now no Air remaining in it, there is no Resistance.

He therefore who rightly comprehends all that we have been saying above, and has learn'd from thence how *Respiration* is perform'd, must be convinced after the most particular manner, that our *Breath* is properly the *Gift* of God; and that it is likewise enjoy'd by Men exactly after the same manner as the *Alms* which a Beggar receives from us. For just as that poor Wretch opens his Hand, and shows it empty, waiting till the kind Benefactor is pleas'd to put something into it, and to fill its Emptiness, and remains passive all the while:

So all Creatures, even self-conceited Man, can only open their Breast, and expose its Emptiness to the great Giver of Breath; being also obliged like the Beggar himself to expect, till the adorable Preserver of all things, *in whose Hand*, as the Prophet *Daniel* tells us, is *the Breath of Kings*, ch. v. ver. 23. vouchsafes to fill the Lungs with *his Air*, by the Help of its Elastick Faculty; which depends alone on the Power of the Creator, and towards which the mightiest among Men can contribute nothing at all. It is impossible to express this in more emphatical and stronger Terms than *St. Paul* has done, in the xviiiith Chapter of the *Acts*, ver. 25. *He giveth to all, Life and Breath, and all things.* We also meet with something of the like Nature in *Isaiah*, ch. xlii. ver. 5. *He that giveth Breath to the People upon the Earth, and Spirit to them that walk therein.*

SECT. XI. *Convictions from the foregoing Observations.*

Now let the proud and haughty Creature, called *Man*, think once seriously with himself, and see whether he can find any Subterfuge, whereby he may avoid owning, that he is obliged, like the meanest Beggar, every time he fetches his Breath to represent his Poverty to his Maker, and his Inability of preserving his own Life, but one minute; and to beg him, that he would vouchsafe to fill his empty and gaping Lungs and Breast, with fresh, good and wholsome Air, and so continue his Life from one instant to another: And can any Body contemplate with Attention, this Nothingness of himself, and absolute Dependance at every Breathing, upon his great Preserver, and the so many Thousand, yea Millions of Times, in which this gracious Benefactor has most freely granted him

him Breath, and consequently, his precious Life, during so many Years; and yet remain, not only ungrateful to him, but even deny all his adorable Attributes and Perfections, even those that he has found so Beneficial to himself; and, if it were possible, wish to annihilate the same. What shall be said of such unreasonable and impious Opinions, but that they ought to be detested by all Generous and Grateful Souls?

SECT. XII. *The Use of Respiration.*

WE shall not here enquire more largely into the Advantage which this Respiration, (the manner of which we have hitherto treated of) gives to Mankind: Since the most Learned Naturalists are not entirely agreed, whether it serves to cool the Blood; or, whether it be to procure a more convenient Passage for the Air alone thro' the little Tubes of the Lungs, and thereby to produce a better mixture of Blood; or lastly, to communicate a Nitrous Spirit to the same in the Lungs; which is believed by many, because, if the Blood running from a Vein, be mixed with Water impregnated with Salt Peter, it changes its dark Colour into a shining Red, and the Serum or Whey thereof, becomes as clear as Water, tho' containing nevertheless, a sufficient quantity of Material Food, as may be observed by putting some drops of the Acid Spirit of Nitre, or *Aqua fortis* therein, which will separate a White Curd from the said Whey: Now the Arterial Blood has likewise the same Property, being dark before it comes into the Lungs: but after having passed thro' the same, and therein undergone the Action of the Air (be it what it will) it discovers a bright red Colour, when discharged into the Left Ventricle of the Heart, and when it proceeds further into the Arteries: And that which is observed by
some

some with greater probability, is, that the Air being *Nitrous*, will change the Blood, that has been drawn out of a Vein, whilst it stands exposed in a *Bason*, from a dark, to a bright red Colour, giving it a Tincture perfectly like that which it acquires by the mixture of dissolv'd *Salt Peter*. We shall pass by all these things, by reason of the Disputes and Controversies of Learned Men, leaving them to be discover'd by the following Ages, and confine our selves only to an Experimental Enquiry, which of the aforesaid Benefits and Advantages, or what other are the true ones that may be affirmed to be communicated by the Air to the Blood.

This is however unquestionably true, That the drawing in of the Air is of so great a Convenience, that no Body could want it long without Dying; and that our Heart, and the whole Structure of the Veins, are formed after such a manner, by the All-wise Creator, that all the Blood of the Body, is made to pass several times in an Hour thro' the Lungs, and there subjected to the Operation of the Air.

SECT. XIII. *The Disposition of the Air in the time of Pestilence.*

NOW, of how great Importance, besides the Elastical Force and Gravity of the Air, the good Disposition and Constitution thereof, is, towards the Preservation of the Lives of Men, and Beasts, is very plain at those Seasons, in which the Air being Corrupted, Pestilential Distempers are occasion'd, and Kings and their Subjects, and Small and Great, are snatched away by Thousands: And these kinds of Diseases must not be ascrib'd to any other Cause, since, being common to all Sorts of Men, they must likewise proceed from one common Source or Spring; and that can be nothing else

else but the Air, which is common to all Mankind. The famous Professor *Schacht* has given us an Account of a dreadful Example of this Pestilential Infection of the Air, in the last Plague at *Leyden*, viz. by exposing a Bucket of Water a whole Night to the Air, even within Doors, upon which in the Morning there stood a kind of a Cream or Scum of divers Colours, that had been communicated to it by the Air; this being gently skimmed off with a Spoon, and given a Dog to drink, the Poison was so Strong, that he died of it in a few Hours: And how pernicious also in general, the Corruption of the Air is, will abundantly appear from the Melancholy Experiments whereby it has been often seen, that People have been miserably Suffocated, and Dyed in an Air to which they were accustomed all their Lives, as soon as that same Air becomes Infected, and Poison'd with the Smoak of glowing Charcole.

SECT. XIV. *The Air leaves something in the Blood.*

Now the Opinion, that the Air being drawn into the Lungs, leaves something there (whatever it may be) and does not come out again of the same Temper, seems to be somewhat probable from certain Experiments, which I have found among my Notes in the Year 1695, by which it should appear credible, that the Air leaves behind it in the Lungs the same Particles which serve to maintain Flame. Concerning this, the Reader may have recourse to the *Ninth Section* of the *Twentyfirst Contemplation* upon *Fire* where the Experiment is shewn in all its Circumstances. Besides which, there is to be found in the *Memoirs of the French Academy of Sciences*, Anno 1707. p. 213. an Observation of Monsieur *Homborg*, where he says, That if any Body has been in a Place where there was a strong Scent of Oyl of Turpentine, he will discover afterwards that his
his

his Urine has the same smell of Violets, as if he had swallowed Turpentine itself. Now since these fine Particles of the Oil of Turpentine do not seem to have enter'd his Body, otherwise than by Respiration, and it being very probable from the smell of the Urine, that they must have been first mingled with the Blood, this Gentleman concludes, that the Air leaves some Particles behind it in the Blood; but we shall not here expatiate upon those things which some People hold uncertain.

SECT. XV. *Convictions from the foregoing Observations.*

Now can any Body, that has well weigh'd and understood all these things, avoid seeing that his Precious Life is in the Hands of another, and how greatly we are oblig'd to shew our Gratitude for his Goodness, in continuing the same: *His*, I say, who preserves this great Sea of Air, in which Men live like Fishes, in such a Disposition as to make it fit to perform this great Office to the whole Race of Mankind, and so many other Creatures, in preserving their Lives and enabling them to breathe? Or, can the same likewise be rectified by any Humane Means, after it is corrupted and become fatal both to Rich and Poor? Now if all this be perform'd by Chance, and without the Providence of a Gracious and Powerful Ruler, how comes it to pass that so many thousand Years, among such great Revolutions that it undergoes, by Storms, Thunder and Lightening; from so many poisonous Vapours exhaling from subterraneous Caverns, and from rotten and putrified Bodies, none of 'em all have hitherto been able to deprive it of that Constitution, by which it preserves the Lives of all Creatures; since if every thing be Accidental, and not under the Direction of a wise Being, the one might as easily come to pass

pass as the other? But of these, and other Properties of the Air, an express mention shall be made in its Place.

In the mean time, let every Body, that has the Knowledge of his Maker and Preserver at Heart, seriously recollect all that has been said about Respiration, and, in a silent Retreat, examine himself, whether he can maintain with Reason, that this Air is not created for this very Purpose among others, in order to preserve the Life of every Creature breathing, since this alone, and nothing else in the World, has the Qualities that are requisite thereto? And let him say, if he dares, that all that most amazing Structure of the Muscles of the Breast, is formed by meer Chance only, without any Prospect of that great End of *Inspiring* and *Expiring* of the Air, since there is here likewise such a great Number of Muscles disposed after so wonderful an Order, to produce that very Effect only, or hardly any other: Can he imagine, that the Lungs were made without Understanding, and placed in the Breast after the manner we have already shewn? Whereas, if they had been disposed any otherwise, all the Properties of the Air, all the Dispositions of the hundred Muscles, which now serve this Work, would be entirely in vain, and the whole Globe of the Earth would be presently dispeopled. Can any one fancy, that so many Ribs and Cartilages, of which the Breast is composed, so many Muscles by which it is moved, together with the Midriff and Lungs, have met one another in such a little Space by meer *Chance*; and that the Air also has encompassed them all without any Purpose; whereas, if but one of these Circumstances were wanting, the great Business of Respiration, and therewith the Lives of all Creatures, would immediately be ended? Can any one think, that where so many and so different
Things

Things concur to one End, the same are not made with this Design, that they shall be useful to each other? He would be ashamed to maintain, that a curious Lock and Key adapted to a strong Box, and by which alone it could be open'd, was not made by an *Ingenious Workman*, but by meer Chance, by which only they had met together. Unhappy Men! that can continue in such senseless Opinions, after so long and daily Contemplations of those Works of the Creation, in which the Wisdom of the Creator is so visibly manifested.



CONTEMPLATION VIII.

Of the Structure of the Veins.

SECT. I. *The Transition to the Veins.*

WHAT has been said seems to be more than sufficient, not only to bring a *Sceptick* into the right way, but even also to convince the most obstinate *Infidel*, that our Bodies must have been formed by a Wise Creator, and that the Origin thereof can be ascribed to nothing less than an *Accidental and Ignorant Cause*; yet, if there should still be any Body who either thro' want of considering what has been already said, finds himself unmoved, and consequently unconvinced thereby; or
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altho' he has understood it, should yet withhold his Consent to the Conclusions that flow from thence; let him go but one step farther with us, and see whether, without a Contradiction of his own Conscience, he can contemplate the wonderful Structure of the Tubes thro' which the Blood circulates, and which are contriv'd for so many Purposes; and then believe, if he can, that He who formed them all, propos'd no End to himself, when he made them, nor knew what He himself was, nor what he had Created.

SECT. II. *The Course of the Arteries.*

Now in order to the compleat Conviction of all such *Atheists* and *Scepticks*, they are intreated seriously to consider with us, whether it can be imagined, that the Vessel (*Tab. II. Fig. 3.*) which is called the *Aorta*, *Arteria Magna*, or *Great Artery*, has, without an over-ruling Understanding or Design, acquir'd such a Form as is shewn from *Verheyen*, in *Tab. III. Fig. 4.* in the particular Scituation wherein it appears in Humane Bodies.

Besides other Wonders which we don't meddle with here, we know, that there is not any one Part of the Body, as yet discover'd, in which we find that the Blood is not convey'd thither by the Branches of this great Artery, either for Nourishment or Motion, and likewise for the Separation of other Humours and farther Uses. Will any Body therefore believe, that this whole Disposition of the Arteries, has been thus contriv'd by Accidental or Ignorant Causes?

Now in order to impart some rough Conception or Idea hereof, which might otherwise appear a little obscure to those that are unexperienced; let us here represent to ourselves the Beginning A O of this Artery, as cut off from the Heart at O,
and

and we shall see two little Arteries *a a*, called the *Coronary Arteries*, coming out of the same, and turning towards the Heart; the same are represented a little bigger in *Tab. II. Fig. 11. B B*.

Then if you ascend as it were streight forwards, you may see in *Tab. III. Fig. 4.* the *Carotides b b*, proceeding out of this Vessel, the Pulse of which a Man may feel with his Finger on each Side of his Wind-Pipe; these having, as they go on, communicated some Branches to the Wind-Pipe and Parts adjacent, do each divide themselves into two Branches, one of which, *e e*, goes into the Head, to the thick Membranes of the Brain, to the Mucilaginous Glands, to the Eyes, to the inmost Parts of the Ear, and to the Substance of the Brain itself; and t'other Branch, *d d*, proceeds to those Parts that compose the outside of the Head, and is the same which is felt in the Temples of the Head.

We may observe farther, that this great Artery begins to bend itself at *A*, in order to descend on the left Side; that on either Side there appear two great Branches *D* and *L*, called the *Subclaviæ*; which, as at *F*, are again divided into two great Branches, one of which seems to terminate at the Elbow, and the other, *E*, carries the Blood to the remaining Part of the Arm, and the whole Hand, quite down to the Fingers: But before this Division at *F*, the *Subclavia* sends out several Branches; such as the Branch *m* downwards to the Breast, and *n*, whose lateral Branches become the superior *Intercostales*; there go farther upwards the *Cervicales c c*, otherwise called the *Vertebrales*, whose lateral Branches at *i i* discharge their Blood into another common Vessel *h*, which like a Chain runs along the Back-Bone downwards. Finally, these *Vertebrales* goes to the Brain. To say nothing more at present of all the little Branches,

ches, as *k*, which go to the Muscles of the Neck, *o p*, to the Shoulder-Blade within and without, and all those which we may observe to proceed from the Arteries of the Arm.

The great Artery turning itself now downwards at *B* and *C*, produces first the *Bronchialis bb*, which seems to feed the Lungs; this is followed by the inferior *Intercostales cc*, which come out here across, and are off; and under these there comes forth sometimes a Branch to the Midriff *d*, under which is the *Celiacale*, which divides itself into two Branches, the Right of which goes to the Stomach, to the Cawl or *Omentum*, to the *Pancreas*, to the Gall-Bladder, and investing Membrane of the Liver; and the left, after having communicated some little Branches to the Stomach, Cawl, and *Pancreas*, terminates chiefly in the Spleen.

Under this *Celiaca*, the uppermost *Mesaraica n*, comes out of the Great Artery, and runs thro' the Midriff to the thin Intestines, in the same manner as the Artery *u* does to the thick ones.

ss Are those that go to the Kidneys and to the Loins; *vv* are the Spermatic Arteries.

After all these Branches, the whole Great Artery divides itself at *w* into two great Branches, called the *Rami Iliaci*, which sending their Branches to the lowermost Bowels of the Belly, as the Bladder, the Matrix, and other Parts of Generation, to the *Intestinum Rectum*, &c. proceed farther on both Sides down to the Legs, and to the extreme Parts of the Toes, after the same manner as the *Vena Subclavia* at *F* does to the Arms.

SECT. III. *The Course of the Veins:*

Now as this great Artery transmits its Branches to all the Parts of the Body, can any one imagine, that not one of them, how little soever,

is to be found, to which there is not again a Vein-branch adapted? Which Branch carries that Blood back to the Heart, that was brought from thence by the Artery, to all the other Parts.

Let those who desire to form any Notion here-of, cast their Eyes upon *Tab. III. Fig. 5.* and observe how these Veins run along the Body, and after having performed their Office, carry the Blood back to the Heart: So that the same Blood which in *Fig. 4.* (to give one or two Instances thereof) was brought from the Heart thro' the *Arteria Subclavia D.* to the Extremities of the Fingers 7, 8, 9, is again received by small Branches of the Vein A N, in *Fig. 5.* by which it returns thro' Q O M G, and is brought thro' a great Vessel E, called the *Vena Subclavia* to the *Vena Cava C.* and so on till it discharges it self again thro' the Orifice A into the Heart.

Thus we here see the Jugular Veins, *Fig. 5. d d, e e,* and the *Vertebrals f f,* bringing back the same Blood, which in *Fig. 4.* was carried into the Head, and other Parts, thro' the Arteries *b b, c c,* and as before, *Fig. 5.* leading it to the Heart A, thro' the same *Vena Cava C.*

We must suppose after the like manner, that the Blood, which was carried down thro' the Artery T, (*Fig. 4.*) and, as in the Arm, driven to the Extremities of the Toes, is there received first of all in the small Veins, in order to bring it back, and farther thro' the Vein I G, *Fig. 5.* along E B, (which is called, *Vena Cava Ascendens*, because the Blood passes thro' it upwards) and discharges itself in the Heart at A.

SECT. IV. *Convictions from both the foregoing Sections.*

Now supposing the same Phænomena in all the Viens and Arteries; can any one imagine, that this great Artery, and the whole Structure of the Veins, are made without Knowledge and Understanding? or that each of them are not thus contriv'd for their particular Purposes, of carrying the Blood backwards and forwards? He that will venture to maintain this, how can he be convinced? And let him but ask himself, if seeing the Pipes and *Aqueducts* of a Fountain (in which there is not the thousandth part of so much Skill or Art as in the Ducts of the Blood) he will dare to maintain, that he really believed they were all disposed after such a manner, without any Wisdom, or Design, or Contrivance of the Master; and that if he should say so, whether he were like to find any Credit with People of good Sense or Reason?

SECT. V. *A rough Representation of the Circulation of the Blood.*

To the end, that an unexperienced Person may, in some measure, comprehend what has been said above, and have some Idea of the Circulation of the Blood, let him suppose, that in *Tab. II. Fig. 3.* the Tubes or Veins E and F, are the same as are represented in *Tab. III. Fig. 5.* by C and B; from which the Blood passes upwards and downwards into the Right Ventricle of the Heart, and thence thro' the Vessel G (*Tab. II. Fig. 3.*) into the Lungs, and thence again thro' another Vein H, into the Left Ventricle of the Heart, which two Vessels H and G, are shewn before, in *Tab. II. Fig. 12* by C E and

H 2 B E,

B E, which encompasses between them both one of the Branches of the Lungs A E : Lastly, let him suppose that the Blood is protruded from this Left Ventricle, by the Contraction or *Systole* of the Heart, into the great Artery I (*Tab. II. Fig. 3.*) which, how it distributes itself by its Branches, has been lately shewn in *Tab. III. Fig. 4.*

So that by this means the way of the so famous Circulation of the Blood may appear to any one that considers the same ; which Blood passing from the Heart thro' the Arteries, to all the Parts of the Body, is transmitted back by the Veins into the same, and then having pass'd thro' the Lungs, between both the Ventricles of the Heart, resumes the same Course again thro' the Great Artery.

He that has ever seen the Circulation of the Blood in the Tail of an Eel, by the help of a Microscope, will be very well satisfied concerning this Motion, without our producing any farther Proofs thereof, tho' they are very numerous ; and he will be no less convinc'd of the great Velocity, or Swiftmess, of the Blood's Motion, if ever he saw it springing out of a cut or wounded Artery.

SECT. VI. *How often the Blood circulates in an Hour.*

Now that we may farther enquire how often the Blood circulates throughout the Body of a Man in the space of one Day, let us agree with the Great *Hurvey* in the following Positions.

1. That the Left Ventricle of the Heart may contain about two Ounces of Blood ; tho' the accurate Dr. *Lower* has often found it larger.

2. That in each Contraction of the Heart, this Cavity is in a manner quite empty ; and therefore two Ounces of Blood are at each time protruded into the Great Artery, which swelling up therewith causes the Pulse.

3. If

3. If we now suppose, that each Pulse is made in a Second of an Hour, or in the 60th part of a Minute, which every one may observe in himself, and is at present, for Conveniency sake, allowed by many, this will produce 3600 Pulses every Hour; and consequently twice as many, that is, 7200 Ounces will pass through the Heart in the space of an Hour.

4. This together will make the quantity of 600 Pounds of Blood (allowing with the Physicians 12 Ounces to the Pound) that will pass thro' the Heart in an Hour.

5. Now it is the common Opinion of the Anatomists, that a Man has seldom more Blood in his Body than 24 such Pounds, or less than 15; but supposing here, with *Lower*, that the same amounts to 25 such Pounds, it is plain, that the whole Blood passes thro' the Heart 24 times in an Hour, that is to say, 576 times in a Day and a Night.

Now if we should maintain with *Dr. Lister*, that there are 75 Pulses in a Minute, or 4500 in an Hour; and that the bare Blood only, which circulates thro' the Heart, without including other Humours, as the Gall, Spittle, &c. which are separated from it, and do not circulate with it, consists of no more than 7 Pounds, as is pretended by some, the same will pass thro' the Heart at least 80 Times every Hour, if he allows 16 Ounces to the Pound; and above 100, if but 12 Ounces; but let the Difference be what it will, it is certain it goes thro' it a great many times.

SECT. VII. *Convictions from the foregoing Observation.*

LET now an unhappy *Atheist* sit down by himself, and fix his Thoughts upon the surprizing Swiftness of the Blood's Motion; let him consider how great the Strength of the Heart and Arteries

must be, which, during the whole space of his Life, produce such a swift Stream of Blood ; let him represent to himself the various Position of such numberless small Branches of the Veins and Arteries thro' which it flows, and having reflected upon the Misfortunes that happen to a Man, in case this Circulation is stopp'd even in the very smallest Branches, and particularly, that all this is brought about in his Body, without any Power of his own Will, and even without knowing or being sensible of what passes : Let him ask himself, whether he can, with a consenting Conscience, maintain, that this whole Structure of the Heart, Lungs, Veins and Arteries, was not produced by a Wise Master; and whether this Blood can be carried about so many thousand Times, for the space of 40, 50, 60, or more Years, through such narrow Vessels, and never cease moving, unless it be by the Direction of a Powerful and Gracious Ruler, who preserves and supports his Life, without the Assistance of any concurring Creature.

SECT. VIII. *Several Particulars. 1. Orifices of the Lateral Branches.*

THAT we may not be too tedious here, we shall pass by innumerable Particulars, which might prove a Powerful, Wise, and Gracious God, even to the blindest of Men ; and only hint at a few, for the further Conviction of those deplorable Philosophers.

Dissect a Vein of an Artery, length-wise, and observe how regularly the Orifices in both of 'em lye ; thro' which, from the latter, the Blood passes into the Branches that Spring out of it, and from the former is receive d into the Vein out of the Branches thereof.

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SECT. IX. 2. *The Arteries grow Narrower.*

Can it be imagined especially, that it comes to pass by Accident, that the Arteries are larger next the Heart, and gradually narrower, and divided into numerous little Branches, as they go farther from it? The reason of which is, to prevent the Blood, which issues with so much Violence out of the Heart, from passing by the Lateral Branches and following its way only in the large Vessels; for if that should happen, the Parts which lye on the Sides, would not be sufficiently provided with their Share of the Nourishing Blood, and so would wither or perish: For it only comes to pass, by this narrowing of the Arteries, that the Blood flowing from the Heart, pushes forwards all that it finds in the Artery, to make place for it self; but that not being able to pass so nimbly because of the Straitness of the extreme Branches, it presses every way upon the Sides of the Artery, and expanding the same (which is the Cause of the Pulse) rushes into the Lateral or Side-Branches with more force than if the Artery had been every where of equal Bigness, or of greater than it had at its Beginning.

And must not every Body confess, that he can, as it were, feel with his Hands our Great Creator's End and Design in these Orifices that are found in the Arteries, and out of which the Side-Branches spring, if he has ever seen the Observations of that exact Anatomist *Lower*, in *Tab. III. Fig. 6.* where at *o b c d*, the Great Artery coming out of the Heart at *o*, and the Branches springing out thereof, *a a a*, making the *Cervicales* and the *Arteria Subclavia*, are represented. Now if the Blood were protruded from *o*, through *b*, and *c*, to *d*, it would pass by these Branches; by reason of the

wideness of the Artery, at least, there would be less Blood communicated to them than was requisite; for which reason the Great Creator has placed such Protuberances at *c*, on the Side of the Orifice, as may in some measure stop the Passage of the Blood in its way from *a*, thro' *c*, to *d*, and cause it to turn its Course into these Branches. Can any one here likewise deny a *Design*, and think that all this comes to pass by *Chance*? Why then does not the same Phenomenon occur in all other Branches, tho' not wanted there?

SECT. X. 3. *The Arteries contract themselves.*

BUT altho' the Blood that comes out of the Heart, does require a sufficient Swiftness by the Contraction thereof, yet there seemed to be Danger that the Heart expanding itself, in order to receive New Blood, two great Evils might happen, *viz.* *First*, That the Blood might by its Weight fall back into the Heart; and *Secondly*, that the contractive Faculty of the Heart ceasing, the Circulation of the Blood might likewise be stopped.

How the former is prevented by Valves, has been already shewn, when we treated of that Matter; and as to the latter, can any one imagine that it happens by Chance and without Design, that in the Arteries themselves, where they have any Largeness, the Membranes of which they are made up (much like what has been said about the Throat) have, besides the Tunic A, (*Tab. III. Fig. 7.*) thro' which the Blood-Vessels for the Nourishment of the Artery, and the Nerves particularly run, and B, where there are many little Glands, still another Tunic C, which consists of several Annular Fibres lying upon one another; and under these the Fourth, D, which is Membranous, and provided with long Fibres running streight forwards. which are thicker, and more fleshy near the Heart.

Now

Now when the Artery is filled by the Blood that comes out of the Heart, to the end that the Circulation should not be obstructed, these Annular Fleshly Fibres contract themselves, and so make the Artery narrower on all Sides; by which means the Blood being prevented from going back to the Heart, is forced to proceed forwards and sideways, and thus the Circulation of the Blood is incessantly continued, even while the Heart is open, and cannot protrude it.

Does not all this *Apparatus* of Instruments, which compose the Arteries, discover that they must have been formed by an understanding Artificer, who has adapted them all to wise Ends and Purposes?

SECT. XI. 4. *The Pulse is not felt.*

BESIDES all this, forasmuch as these Arteries spread themselves thro' our whole Body, and at every time upon each Contraction of the Heart are expanded with so great a Force, and do Day and Night occasion so strong a Beating as we find by the Pulses, who can conceive the Reason why we are not sensible of it as long as we are in Health, notwithstanding that we may find them beat so strongly in many Places, if we do but lay our Finger upon them?

'Tis true, that some lay it down for a Maxim, *De consuetis non judicat Anima*; that is, *Our Mind does not judge of that which we are used to do.* But if this were true, we should judge as little of our *Respiration* as of our *Pulse*, being accustomed as much to the one as to the other; and yet we find, tho' we often breathe without thinking of it, that with never so little Attention we can perceive the Motion of the Air in our Mouth, Nostriis, Wind-Pipe, and Lungs, and discover from the Action it self that we breathe; whereas, on the contrary, let
a Man

a Man that is in good Health attend with as much Care as he can to the Beating of his Heart and Pulses of his Arteries, he shall not perceive them in the least.

Does there not then appear, in a very particular manner, the Wisdom and Goodness of our Great Creator in this matter likewise, who, that the Attention which we ought to allow to other things, might not be disturbed by this continual Pulsation, has been pleased to render us insensible of it? And tho' an Atheist cannot, or will not, see this, yet whoever acknowledges a God, may learn from thence, that it is his Duty to fix his Thoughts upon his Maker and his Works, who has so graciously wrought this Wonder in him, to the end that his Attention should not be drawn away by this continual Beating of the Arteries.

Nor can any ascribe this to any material Property of the Arteries themselves, forasmuch as every body is but too sensible, to his own Damage, of all these Beatings, when in a Fever, or other Distempers, the Fibres are extended by the Blood more strongly than usual. The same may be observed particularly, when in great Disorders and Frights the Annular Fibres are contracted more narrowly, and after a cramping manner, than they ought to be, by the irregular Motions of the Humours of the Nerves which move the Arteries; so that these Vessels being become streighter, the Violence which they suffer from the Blood issuing out of the Heart, is more sensible than usual. This is known to them that have heard the Complaints of some Women, who (as it is said) being subject to sudden Disorders upon the least Accident, do many times feel their Arteries beat throughout their whole Body.

I don't know whether it may be useful to add here, that the Contraction of the Arteries, and other Parts of our Body, upon the Account of Frights,

Frights, seems in some Measure to be confirmed, because in such great and Heart-affecting Motions, the whole Body is often put into a cold Sweat, which is known to proceed from the Contraction of the Glands in the Skin, that are thereby forced to protrude their Moisture; and if there be any small Hairs planted in these little Glands, they will rise up an end by the Contraction of the same; which Phænomenon People may have often observed upon a Fright, not only in themselves, but in Beasts too.

SECT. XII. 5. *The Concurrence or Conjunction of the Veins.*

IF it be not owing to the Wisdom of the Creator, that there is no Part in the whole Body to which the Blood does not extend itself, and from whence it likewise returns; how comes it to pass, that Arteries meet Arteries, and Veins meet Veins so frequently, and discharge their Blood into each other, to the end that if any of 'em all should be disabled by Amputation, Obstructions, or otherwise, the Blood might pass another Way to or from the same Place?

SECT. XIII. 6. *The Division of the Arteries into Capillary Tubes.*

TWO Things more may be observed, touching the Circulation of the Blood thro its Vessels; in which, no less than in the foregoing, the Wisdom of our Adorable Creator shines out as clear as the Sun at Noon-Day.

The *first* is, that from the strong and swift Motion of the Blood in such Arteries as are large, there seems to be a Danger, that by reason thereof the Blood cannot contribute any thing towards
the

the Nourishment of the Vessels themselves thro' which it runs so fast. Can one consider then without Amazement, that, to obviate this Inconvenience, the Arteries are divided in those Places where this Function is required, into an unspeakable Number of fine and narrow Tubes, which the Anatomists, by reason of their Smallness, are wont to call *Vasa Capillaria*, or *Vasa Minima*; that is to say, Vessels that are as small as a Hair, and so little, that they cannot therefore be described among the Arteries in *Tab. III. Fig. 4.* and all this to the end, that by passing thro' these *Defiles* or *By-ways*, and sticking to the Sides of such narrow Vessels, the Blood might proceed more slowly where it is necessary that it should do so, whilst that which passes thro' Vessels something wider, may pursue its Course to the Veins with greater Swiftness.

SECT. XIV. 6. *The Narrowness of the Tubes lessens the Swiftness of the Blood.*

Now that a fluid Body protruded with the same Strength, runs more slowly through narrow than wide Pipes, for the above-mention'd Reasons, is well known to all Fountain-Makers, who can make the Pipes, through which the Water is to pass, so narrow, that by the sticking of the Parts of the Water to the Sides thereof, the Stream shall not rise near so high as it would do thro' larger Pipes: And if any Body doubts this, he may have an ocular Demonstration of it, by the following very easie Experiment.

Let him take the Glass Tubes E F G, of different Bore; (*Tab. IV. Fig. 1.*) of those we made Use of (as I find it upon my Notes) one of 'em E, was a narrow Neck of a broken Thermometer; the Second F, was something larger, and about the

the size of the Tube of a Barometer, or the Quill of a Pen; the Third G, was so large that one might thrust one's Finger into it. Then let him tye a little Thread about each of 'em at H, K, M, so that their Parts HI, KL, MN, may as near as possible be of equal length; and putting them into a long Glass, A B C D, which is filled with Water up to A B, let their lower Ends, I L N, reach almost, but not quite to the bottom D C, in such manner, that the Threads H K M, may be even with the upper Surface of the Water: Then if he stops these Tubes with his Finger, at E F G, and thrusts them (being empty, or rather full of Air) one by one, perpendicularly down into the Water, and suddenly remove his Finger from the Orifice, he will see the Water in the narrowest Tube E, rise up even with, yea, visibly above the Superficies of the External Water H: Whereas in the Tube F, the Water will rise up as high as O, and in the Tube G, yet higher to P. Now those that are skill'd in *Hydrostaticks* know, that equal Parts of Water lying in the horizontal Superficies Q R, which passes under the Orifices of the three Tubes I L N, are pressed upwards with equal Force; and therefore, that the lesser Force, which appears in the ascent of the Water in the narrowest Tubes, must only be ascrib'd to the greater Narrowness thereof.

Now whether the Curvity of Angles, made by these little Branches of the Arteries; as also, whether their Multiplicity (so that being taken together, they may by reason of their Numbers, have more Wideness than the great Artery alone) do contribute any thing towards the slower Motion of the Blood, we shall not enquire farther here.

SECT. XV. 7. *The Veins grow wider.*

THE *Second* thing is, That in case the Blood, which thro' larger Vessels runs swiftly along the Arteries, should retain the same Swiftneſs in the Veins, by which it is carried back again into the Heart, there would be Danger that the Heart should be overwhelm'd with too much Blood, and the Right Ventricle of it filled ſo full, that it could not be able ſufficiently to exert its contractive Faculty.

Now to prevent ſuch pernicious Swiftneſs, could any body have thought of a wiſer Expedient, than to have made theſe Veins larger and larger, as the Blood came nearer from the extreme Parts to the Heart, as may be ſeen in *Tab. III. Fig. 5.* quite contrary to the Arteries, which in *Tab. III. Fig. 4.* grow continually ſmaller from the Heart to the Extreme Parts.

Now that a Liquor paſſing thro' a narrow Veſſel into a wider, runs ſlower in the ſame Space of Time, is obvious enough to every one, without proving it experimentally; but if he has a Mind to ſee it that way likewiſe, let him fill a Pipe with Water, and thruſt it with its Orifice downwards, into a Bucket, which has likewiſe Water in it to a certain Height, and forcing the Water as faſt as he can out of the ſaid Pipe, he will find that the Water in the Bucket will aſcend but to a very ſmall Height, tho' all that was in the Pipe came out of its full Length at the ſame time; from whence it appears, that the Water in the narrow Pipe moved more ſwiftly than that which was in the wider Veſſel: But this is ſo plain, that we need ſay no more of it.

SECT. XVI. 8. *The little Valves in the Veins.*

BUT since the Blood moving more slowly in these Veins (*Tab. III. Fig. 5.*) might, by reason of its Weight, (especially in those that carry it directly upwards) endeavour to sink down or go back, and so in long Tubes forcibly resist this slower Motion; may we not again discover here the Providence of the Creator, exerting itself in so peculiar a manner, who has thought fit to place little Valves in these Veins; sometimes but one, as in *Tab. IV. Fig. 2.* at A; sometimes two together, as at B B, whose Office is to stop the Blood when it attempts to go back, and that it may not, by its Weight, press too much upon that which follows, and thereby retard its Motion?

Now, is all this done by Chance, and without Design? Why then are these Valves fixed in the Veins, where they are so serviceable, and not in the Arteries, where they are so far from being necessary, that they would be prejudicial?

SECT. XVII. 9. *Of the Fibres in the Veins and Arteries.*

WE must add one thing more, and so conclude these Remarks, which would otherwise, as is well known to those that understand it, swell to a much greater Bulk: Can any Rational Man then persuade himself, that the Great Creator had no End at all, or that it come to pass merely by Chance, that in the Arteries, where the Blood stood in need of more Strength, in order to insinuate itself into the narrow Passes of their extreme Branches, the muscular Fibres, by which they are contracted, are very strong in those Parts; and on the contrary, in the Veins, which continually grow larger, and
in

in which too great a Swiftneſs and Contraſtion would be hurtful, the Fibres are far from being ſo ſtrong or ſo numerous? But that which the Wiſe Creator cauſes us to feel as it were, with the Hand, is, that in the *Vena Porta*, the like Fibres are again ſtronger than in other Veins, tho' fewer than in the Arteries; thoſe being the only Veins of all thoſe of the Body, whoſe Branches, entering into the Liver, grow narrower and narrower; for which Reaſon they require more Strength than other Veins; to the end, that like the Arteries, they may force the Blood to paſs on to the narrow Ramifications, and to the Glands of the Liver.

Now if any one has conſider'd and underſtood what has been juſt now ſaid, and particularly that about the Structure of the *Veins*, can he poſſibly doubt any longer whether his Body was framed with Wiſdom? And does it not follow plainly enough from hence only, that nothing elſe is neceſſary towards a Conviction that there is a God, (provided he himſelf vouchſafes to bleſs the Means) than to enquire into his Works, even into the ſmalleſt Fibres? And the neglecting or deſpiſing ſuch Enquiries has been the undoubted Cauſe that ſo many People walk in Darkneſs, in the miſt of the bright Rays of God's Wiſdom. I know very well that inſolent Atheiſts will think all theſe Obſervations and Reflections to be of little Moment, and much below their lofty Speculations, as being ſo obvious even to thoſe that are juſt enter'd upon the Study of Phyſick: But I know likewiſe, that as contemptible as they may appear to thoſe conceited Men, it is impoſſible for them to believe, much leſs to prove, that all theſe Parts were form'd by Chance.

SECT. XVIII. *The Uses of the Blood in general.*

Now to pass by other Particulars concerning the Blood and Veins, of which we have already treated very fully, the Thread of our Discourse seems to lead us to the Uses and Motions of this Blood.

There are Three particularly, that, among others, are known to depend either wholly, or in part, upon the Blood: The *First*, is the Separation of so many different Humours, which are either necessary to the Body, or must otherwise be discharged. *Secondly*, the Nourishment of the Body. *Thirdly*, the Motion of the Muscles.

Now whilst we are going to treat of the first of these in its order, let no Body think that we design to enumerate the various Opinions of many learned Men thereupon; being contented to shew the external Disposition of some, so far as it is known, since Men have not yet been able to penetrate all that belongs to it, besides, it was both out of our Power and Design too, to handle this Matter alone in this Place. A rough and general Account of the Uses of these separated Humours will be more than sufficient for our Purpose, which was to convince a sceptical Mind, that we are formed by a God abounding with Wisdom and Goodness.

And can any one still ascribe to ignorant Causes, which don't even know how, or whether they work at all, that the Blood, and all the nutritious Juices are impetuously hurried along such wonderful Vessels, as has been shown above, thro' the whole Body, in order to furnish Matter for the so necessary Separation of such a vast Number of different Liquors?

SECT. XIX. *The Enumeration of several Humours.*

NOW to pass over the *Lympha*, which is separated in so many Places, the Gall in the Liver, the Juices in the Pancreas, and in numberless other Glands, the Humours in the Stomach and Intestines, in the Eyes, Nose, Ears, Mouth and other Parts; forasmuch as there are still different Opinions about them and their chiefest Uses: Can one see that there is discharged from the Brain so powerful and spirituous a Humour, which is derived by the Nerves to all the Parts of the Body, rendering so many and such important Services, and being particularly the chiefest Cause of all our Motions; that there exhales from the Pores of the Skin, and by Respiration, an invisible and continual Vapour (supposing a Man to be in good Health) in so vast a Quantity, that the accurate *Sanctorius* has discovered, that this alone does exceed every Day all the other grosser and visible Evacuations?

Can any Body believe, that it happens without a fix'd Purpose of our great Preserver, in order to continue upon the Earth the Race of Mankind in their Children, that the *Materia Seminalis*, for the Procreation of them, is separated from the Blood; and that the Milk flows from the Breasts of the Females for the Nourishment of these tender Sucklings? Can any Body contemplate the Dispositions of the Water-Courses, when the Blood is separated from its Salts in the Kidneys, without discovering the Finger of his adorable Creator in all these Things?

SECT. XX. *The Passage of the Urine.*

And to the end, that all that has been here said may not pass for Declamation, or Rhetorical Figures,

figures, let us examine a little more closely the Dispositions that are made in the solid Parts of the Body, for these three last mention'd Humours; without enquiring into that great and wonderful Mystery, how each of them has acquired its peculiar Faculty or Property, which hitherto remains among the Secrets of the great Creator.

Now to give some Notion thereof to an unexperienced Person, let him suppose, in *Tab. IV. Fig. 3.* that the Blood descends from D to u, thro' the great Artery Du, of the Heart; and because the said Artery at u, and in the farther proceeding Branches, grows continually narrower, that the said Blood is forced to pass into the Side Branches; by which means it takes its Course thro' one of them, F, to the Kidney B, where having discharged its Salts, it returns by the Kidney Vein W, and so proceeds by C, along the *Vena Cava* upwards, again to the Heart.

In this Kidney (the internal Structure of which is represented (*Tab. IV. Fig. 4.*) the Humour of which the Urine is composed, seems to be separated in the outmost Glandulous Substance, A A: Do we not here, without going any farther, perceive the wonderful Operation of the Designs of the adorable Creator, who makes this Humour descend thro' such narrow Vessels B B, which being collected into a kind of little Nipples, called by the Anatomists *Carunculae Papillares*, do filtrate this watry Matter with its Salts into larger Membranous Vessels, ccc; which do again discharge what they had received, for the most part, into two great Spaces, out of which there is made one great one, C, called the *Pelvis*; thro' the Orifice thereof this Liquor descends farther into the Tube D, or the *Ureter*, which being joyned to the *Pelvis*, do represent a compleat Funnel with its Pipe, which being inserted at Y Y, (*Tab. IV. Fig. 3.*) in the Blad-

der H, makes on each side a Vessel G Y, in order to discharge that which is brought into it?

Two things seem to be requisite here; *First*, that the Urine coming in o the Bladder, may be driven out again; and, *Secondly*, that in order to prevent Inconveniencies, it should not happen continually, not without our Will. Now can it be imagined, that it is without Knowledge and Design, that there should be Muscles likewise placed in the B'adder, in order to contract it, and force out the Water, besides the Muscles of the Belly which could have pressed it; and particularly, that tho' the Bladder were contracted and drawn together, that which is contained might have burst out at every Orifice, if it had not been so contrived, that that Humour should not be able to return thro' the Orifice Y Y, by which it descended from the *Ureters* G, but only thro' that Passage which Nature has prescribed it?

Thus we see that it is easie to blow up the Bladder H, by one of its *Ureters* GY, but if it should be blown by that Tube, thro' which the Urine comes out, the very Children know, that the Wind cannot pass that way thro' the Orifices of the *Ureters*.

And as for what relates to the second Thing, we may observe, that the Bladder is fortified with a strong Muscular Valve at the lower end of it, to prevent the Leaking of its Humour, and is shut up by the same till a greater Force obliges it to give way, and suffer the Water to pass thro' it.

Add thereto, that because this Humour is almost always Salt, and often sharp, the most gracious Care of our Creator (to the end, that it should not corrode the innermost Membrane of the Bladder, which is exceeding sensible, and so occasion Pain) has fortified the same with a kind of a tough and slimy Moisture against it in the inside.

SECT. XXI. *The Breasts of Women.*

THE same Wisdom appears in the adapting other Things to their Ends, such as the Tubes of the *Ductus Salivales*, and especially in the Structure of those Ducts, by which the Gall passes from its Bladder, and from the Liver to the Intestines; and the Vessels of other Parts, where the Humours are separated from the Blood.

But can he, who sees no more than the little Glands A A, in the Breast of a Woman (*Tab. IV. Fig. 5.*) (the external Tegument being taken off) in which the Milk is separated from the Blood; and the little Tubes *bb*, into which it flows, and where it is preserved, to the end, that it may in proper time be suck'd out thro' the Nipple C, where they are open, and in which they terminate: I say, can he that sees these Things imagine, that this only Part, to deduce no Arguments from all the rest, had not a Maker, who destined it to perform a Service so very important to all Creatures in their most tender Age?

SECT. XXII. *The Structure of the Seminal Vessels.*

Now that every one maybe yet farther convinced, that all the Parts of our Body are with great Wisdom adapted to particular and certain Uses; let us go on, and consider the other Parts represented in *Tab. IV. Fig. 3.*

1. How the spermatie Arteries P P, coming on each side out of the great Artery *D u*, do descend to the Testicles, therein to discharge the seminal Matter which they bring thither with the Blood the Remainder of which is carried back again from the Testicles to the Heart by two Veins O and *n*, and with how many Windings and Turnings

the same ascend, may be seen on the left Side *o o*, where they are represented as stretcht out; whilst the Artery *P*, descends streight forwards in a Man, as *Verheyen* has observ'd.

And, that we may all see that the Wisdom of our Creator extends itself to the meanest Things, it need only be observ'd, that the Arteries *P P*, do, for the most part, proceed immediately from the great Artery *D u*; but that the Veins *O* and *n*, thereto belonging, do not both, but only one of 'em, viz. *O*, and on the Right, discharge itself into the *Vena Cava C u*, whilst the Left *n*, is inserted into the Kidney Vein *W*, because it was to be feared, that as it took its way into the *Vena Cava C u*, the course of its Blood might be obstructed at every swelling of the Artery, by reason of the continual Pulse of the great Artery, over which this Vein must have necessarily pass'd, as appears by the Figure; so that by this Conveyance of the Blood, from *n* to *W*, and from *W* to *C*, (which otherwise, if it ran as at *O* would be shorter) this Inconvenience is prevented by a careful Providence, and it is fully prov'd, that it intervenes in so small a Matter as the Course of this Vein.

2. That in order to bring the seminal Matter, separated from the Blood in the Testicles, to its destin'd Place; two Tubes, *R R*, or the *Vasa Deferentia*, ascend from the said Testicles, and carry the Seed into the *Vesicula Seminales*; which appear on one Side behind the Bladder *X X*, and there it is preserv'd till the time of its Use.

3. That the End of these Seed-Vessels is stop'd by little Glands, which prevent the Matter from distilling out of its own accord, and yet do not obstruct the same when an Ejection is necessary.

4. That in each of the Groins there is a peculiar Tube made for that purpose, of the Membrane that lines the Belly, call'd the *Peritonæum*, thro' which

which the feminal Vessels or *Vasa deferentia* R R, ascend; as may be seen *Tab. II. Fig. 1. W W.*

And particularly, to prevent the Intestines from pressing into the *Scrotum* or Cod, and causing what we commonly call a Bursten or Broken-Belly, these Tubes are cover'd with a Membrane in *Men*; but in Dogs, and other Creatures, whose Posture is not erect, and consequently which are in no danger of such Accidents, the same Tubes have no Coverings but are quite Open.

SECT. XXIII. *Convictions from the foregoing Observations.*

THERE are whole Volumes written to shew all the Particulars of these Parts only; we shall therefore go no further, but leave it to every one that reads and understands what has been already said, to examine himself, whether he can believe, that in all these Matters about the *Seed, Bladder, Breasts, &c.* the Wisdom of a Creator has had no Room; and whether he can admit, that among thousands of Differences, any one of which, in case all things had been produced by Chance, and without Understanding, might have here equally come to pass, these only should have taken effect; all of which are so well adapted to such great and necessary Purposes? I can't forbear saying one word here likewise to some other Philosophers, and observe, that since, as we have just now shewn in *Tab. IV. Fig. 3.* the spermatic Vein *n*, on the Left Side, does not take the shortest and most simple Way to the *Vena Cava C u*, as that on the Right Side does in *Q*; but making a Tour, does first insert and discharge itself in the Kidney-Vein *W*; that it is in vain to affirm, that those Hypotheses carry the greatest Truth with them, which appear to us to be the most simple, and to produce

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every thing after the shortest Manner; forasmuch, as there may be unknown Reasons, as here in the Case of the great Artery *Du*, why the supreme Architect, in order to bring about his other Purposes, may think fit to depart from that Method, which would otherwise be more short and simple in the Production of that End only.

SECT. XXIV. *The Nourishment and Motion of the Blood, not yet fully known*

NOW it would be time to pass on to the other Uses of the Blood, namely, the *Nourishment* and *Motion*: But forasmuch as the Ways of the great Creator, are in these Matters, even to this time, inscrutable to us, and that the Structure itself of the solid Parts are not yet fully known, but affords room for Disputes; we judge it more safe to be silent therein, than purposely to offer only Guesses and Uncertainties, or Positions, which are not yet sufficiently received by learned Men; how probable soever they may seem; the adorable GOD has not however left himself without a Witness, to every one that seeks him, in numberless other Matters, the Certainty of which, can by no means be called in Question.

In the mean while it is in some Measure plain, how justly the Creator speaking in the Holy Scriptures of *Generation*, says, that Children proceed from the *Loins* of their Parents. *Gen. ch. xxxv. v. 11 Kings shall come out of thy Loins.* And again, *1 Kings. ch. viii. v. 19. and 2 Chron. vi. 9. Thy Son which shall come forth out of thy Loins.* Since *Tab. IV. Fig. 3.* the feminal Vessels *P P*, are separated in the *Loins* and under the Kidneys *A* and *B*, from the general Stream of the Blood in the great Artery *Du*; in order to carry the Matter of the Seed to Places prepared for its Separation. Besides that
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Monſieur *Verheyen* ſays that he has obſerv'd both in Men and Women, a remarkable Vein and Artery (repreſented here by *p p.*) which proceeding from the undermoſt Part of the Kidneys, joyns itſelf to the feminal Veſſels.

This kind of Expreſſion is perfectly underſtood, ſince the Diſcovery of the Circulation of the Blood ; and ſhows with how much knowledge it has been apply'd to all Animals, even at a time when the Structure of their Bodies was ſo little known to the World ; at leaſt, none could with any Shadow of Reaſon aſcribe the Buſineſs of *Generation* to the *Loins*, without knowing that the Blood circulated thro' the Arteries, O and P. Now that this was a Secret to all the Philoſophers, and Phyſicians in thoſe Ages, is ſo obvious, that we need not take any Pains to prove it. Can it therefore be imagin'd, that the Texts above-mention'd, which ſo plainly declare the ſame, could be writ by any uninspired Perſon. And if any one ſhould ſeek to cavil againſt the Arguments we have here uſ'd ; at leaſt, he cannot deny that the ſaid Text ſpeaks with compleat Knowledge of the Cauſe, and deſcribes this Matter juſtly.





CONTEMPLATION IX.

Of the Nerves, and briefly of the Lymphatick Vessels, Glands and Membranes.

SECT. I. *The Transition to the Nerves.*

WHEN we were treating about the aforesaid Separation of the Humours of the Blood, it would have been proper enough to have mention'd those of the *Brains and Nerves*, as a kind of Humours; but with respect to our Design, the so important Use thereof, the so wonderful Texture of the whole Series of the Nerves, which, like the Arteries for the Blood, serve for Vessels to convey these Humours are by much too considerable to be handled cursorily, without saying something particular of them too.

Now then, in order to convince an unhappy Philosopher, of the Perfections and wise Designs of his Maker, nothing more seems to be required, than to move him to look into the Enquiries and Observations of the Anatomists, and especially of *Willis* and *Vieussens*, and endeavour to acquire a just Idea of the Concatenation of this wonderful Structure, of the innumerable Multitude of the little Branches of the Nerves, of which there is
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not one that is made, but what is of great and peculiar Service to the Body.

To represent something of this Matter here, let him cast his Eyes upon *Tab. IV. Fig 6.* and consider, if each of these fine Branches performs its Function, (and some of 'em are so very necessary, that if they cease, they put an end to our Lives;) whether these Nerves that appear to the Eye of an unexperienc'd Person, so irregular and confused, and yet in themselves are so well disposed, that there is not one of 'em, yea, not the smallest Branch or Sprig of 'em but has its Use; let him consider, I say, whether all this can be performed by Chance? He that desires to be more fully convinced hereof, let him consult the large Figures of Mr. *Vieussens*.

Leaving therefore further Circumstances and Particulars, which we might have added here, to the Study of those who think fit to inquire into what those Writers have said upon this Head, we shall only observe a very few of them, that we may not appear too prolix.

SECT. II. *Different Opinions about the Matter that passes thro' the Nerves.*

IT was well enough known to the Ancients, that all the Nerves are a kind of Vessels, thro' which a certain Matter, that descended from the Brain into the Muscles, was either an entire, or at least a concurrent Cause of their Motion: Because, if a Nerve was cut off, obstructed, or otherwise disabled, the Muscle to which it belonged, notwithstanding all Endeavours to the contrary, would remain without Motion.

This Matter is conceived by all to be indeed fluid; but by some 'tis supposed to be a Wind or Spirit, and is therefore called the Animal Spirits, and is believ'd to pass thro' the Nerves with a
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Swiftness like that of Lightning ; it being otherwise impossible to reconcile the unconceivable quickness of the Motion, which we see performed by Creatures in so short a Space of Time, with the slow Course of a Liquor : Upon this Foundation, there are supposed to be Valves, and many other things in the Muscles, in which Suppositions there is Ingenuity enough, if there were but enough of Truth too.

But these Opinions are called in Question ; *First*, because it has been sufficiently proved by Chymical Experiments, that so very volatile a Matter is not always required towards the producing a swift and violent Motion ; accordingly, it has been seen, that by the Mixture of Oyl of *Vitriol*, and Salt of *Tartar*, the first of which has little, and the other hardly any Volatility in it, a strong and sudden Fermentation has been produced. We are taught by a like Experience too, that *Salt-Petre*, *Brimstone*, and *Charcoal*, which are not counted among volatile Things, being mingled together into *Gun-Powder*, have occasion'd such Motions, as for Swiftness and Force, have not yet been equal'd. The same appears from the *Glass of Antimony*, which being a fixed Body, (or at least so little volatile, that it is able to resist a very strong Fire for a long time, as is well known to the Chymists) has yet the Faculty of producing such great Comotions and Contractions in humane Bodies, even so small a Quantity of it, that those who have tried it own it to be wonderful : Others deduce the Motions of the Muscles from Hydrostatical Laws, which therefore need not suppose so great a Swiftness of the Nervous Juices.

Secondly, the Course of the Nerves being now better known to the Anatomists, it has been discover'd by the Complaints of their Patients, that it was probable, that a slowly moving Matter passed

pass'd thro' the same; which seem'd to be in some manner more credible when it was consider'd, how improper the moist Substance of which the Brain and Nerves are compos'd, appear to be, for affording a free Passage to any thing that was to move thro' them with so unconceivable a Swiftness, as the Matter of Wind and Spirits.

SECT. III. *An Experiment to prove a Nervous Juice.*

BUT particularly the Experiments taken afterwards by Messieurs *Ballini* and *Malpighi*, seem to have put the Matter beyond Doubt, and to prove, that there is a tough Humour (which they call'd *Succus Nervosus*, or the Nervous Juice, in Opposition to the *Animal Spirits*) that runs thro' the Nerves.

For if you dissect the Breast of a Creature, in which there is still a little Life, or that is but just dead, and with the Fingers of one Hand, press the Nerve of the Midriff in such a manner, that nothing can descend from the Brain into it by this Vessel; and after that, go on to press with the other Hand, that Part of the said Nerve, which is between the first Pressure and the Midriff, so as to drive whatever it contains forward into the Midriff; it will be found, that the Midriff will resume the Motion which it hath lost, and continue it till the Humour that was in the Nerve be quite protruded: But if you loosen the Fingers of the first Hand, and admit a new Passage to that which comes from the Brain, you will see after some Time, that, as soon as this new Humour reaches the Midriff, the Motion of it will be renewed. Consult *Bergerus* upon the same, Page 260. And, that one may have some solid Foundation, that the Matter of the Nerves is of the Nature
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of a Liquor; and not of a Spirit or Wind, the diligent Enquirer, *Malpighi*, has shewn, that by pressing the End of the great Nerve, in the Tail of an Ox, the same will swell before your Finger; and if you make an Incision in it, there will come out a viscous Liquor like Turpentine. Which Experiment having been several times prosecuted by *Bergerus*, and always appearing in the same manner, it puts the said Hypothesis out of all Doubt.

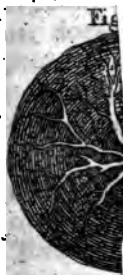
SECT. IV. *Corrections from the foregoing Observations; and an Experiment about Motion.*

I WOULD ask any Body now, that understands this; whether it can seem credible to him, that it is brought about by Chance only, and not for any wise Purpose, that a Humour, which is separated from the Blood in the Brain, is derived into every Part of the Body, by such an innumerable multitude of Tubes and Channels, in order to produce Motion wherever it is requisite? To say nothing here of the Fermentation of the Food, of Nourishment; and so many other Uses, which render the Course of this Nervous Juice entirely necessary: And can it be without an End, that this Humour has one wonderful Property, (more we cannot reckon here with any Certainty) that it is fitted, together with the Blood of the Arteries to produce these Motions in the Muscles?

For that the Arterial Blood does likewise very much contribute to Motion, may appear from the Experiments of *Bartholinus*; by which we see, that a Limb or Joynt is render'd lame and void of Motion, as well when, by binding the Artery, the Blood is hinder'd from coming into the Muscles; as when the same is done to a Nerve. And can any one observe this come to pass, after such

Continuing page

Fig. 4



such an amazing manner, not only in *one*, but in all Men and Beasts too, and so many Wonders produced thereby; such as the external Motions of Walking, Swimming, Flying; and the internal of the Heart, Arteries, Stomach, Bowels, and so many other Parts, serving both for the Support and Procreation of Animals; and, can he then ascribe all this to mere Chance and ignorant Causes, without thinking that he will be taken, by wise Men, for a blind or obstinate Fool?

SECT. V. *The Nerves of Hearing are extended likewise to the Tongue.*

NOW let a Man consider farther with himself, whether the great End of our Creator, to furnish us compleatly with every Thing that is necessary for us, does not plainly appear in the following Cases: *First*, That the Nerves of *Hearing* do distribute their Branches to the Muscles that move the Ear, to the end, that as soon as we are warned by the Noise, which affects the Nerve, the other Instruments may be immediately put into a Condition of erecting the Ear, in order to listen the better: This is observable in the raising the Ears of many Creatures as soon as you speak or call to them; for the same Reason it is, that this Nerve sends other Branches to the Eyes also, that upon the hearing of any uncommon Sound, we may presently look about us; and likewise, be ready, without Delay, if speaking or calling for Help be necessary: for which Purpose, the said Nerve of *Hearing* has a Communication with those of the fifth Pair, and the Parts that produce Speech.

SECT. VI. *The Nerves of Tasting.*

Secondly, THAT the Nerves which serve to produce *Taste*, and which, accordingly to *Willis*, make a fifth and sixth Pair, do likewise send out Branches to all those Instruments that are necessary for Mastification or Chewing, to render the Action and Taste lively and ready; they likewise send other Branches to the Nose and Eyes, to the end, that in the Choice of our Victuals we may be assisted by the Smell and Sight: And lastly, that while all the forementioned Properties are exerted, to the end, that nothing may be wanting, other Branches are transmitted to the Glands for Spittle, that this Humour may be supplied in abundance, and the Mouth and Throat moisten'd therewith, during the Action of Chewing and Tasting.

SECT. VII. *Nerves that operate with, or without our Consent.*

Thirdly, CAN any one see without Astonishment, that Nerves, which seem to be made of the same Matter, and maintain'd by the same Food, can perform such various and different Functions? That the first, which come out of the Marrow of the Back, as the said Marrow does from the fore-part of the Brain, should entirely be governed by our Will, in the Motions produced by them in our Arms, Legs, &c. and accordingly cause the Muscles to operate, or to cease working; whereas the other, that have their Origin in the *Cerebellum*, or Hinder-part of the Brain, do continually and incessantly move those Parts to which they are transmitted, as long as our Life lasts, without the least Subjection to our Will.

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SECT. VIII. *The Parvagus and Intercostal Nerves.*

WE shall give a Proof thereof, in *Tab. IV. Fig. 6.* which, by reason of its Smallness, can only shew us a little of it: *A B* is the *Parvagus*, or Wandering-Nerve, as it is called by the Ancients, because it is extended to so many Parts; by *Willis* it is called the eighth Pair; of this, *A* represents the uppermost *Plexus*, and *B* the following; after some Ramifications to the Muscles of the Throat and Neck, there goes out of *H*, a Branch *a*, to the upper-part of the Wind-pipe, there come several other from *B*, which extend themselves to the Heart, to the *Pericardium*, and to its Auricles and Blood-Vessels, and one bigger than the rest, *C*, which runs to the *Plexus Nervosus* of the Heart *F*; from the *Plexus B*, there springs likewise the recurrent Nerve *D* on the right Side, and *E* from the Body of the Nerve itself on the left Side, which moves the Wind-pipe.

Besides these, there goes at *e*, a great Branch to the Vein of the Lungs, and to the Heart at *D*, and from the *Plexus Nervosus* of the Heart *F*, runs a Branch *e*, to the Artery of the Lungs, and a great many, *f*, to the Heart.

Moreover, there pass from this Nerve a great many Branches *g*, to the Lungs, and the Veins and Arteries, and *Bronchi* of the Lungs in the same, and some, *h*, to the Gullet.

Finally, this same Nerve divides itself into two Branches, *G H*, on each side, which afterwards uniting again in *I*, spreads an unspeakable Number of Branches in the Stomach; and, after having sent some Sprigs to the *Plexus Nervosus*, lying in the Belly, ends there, as far as we have been able to discover.

The fifth and sixth Pair of Nerves (marked 5 and 6) the first of which does in a manner furnish all the Parts of the Face and Mouth with Nerves, make a great Nerve by the Branches which they send out, and which are commonly called, tho' not very properly, the *Intercoſtal*; this, after having made a *Plexus* above at *i*, and transmitted out of it a Branch to the contracting Muscle of the Gullet, proceeds forward to a second *Plexus* *K*, which lies in the Neck; and after having sent out of it some Fibres *λ*, to the Gullet and Wind-pipe communicates farther great Branches *L*, to the *Plexus Nervosus* of the Heart. Again, this same Nerve makes a third *Plexus* at *N*, and then descends thro' the Breast, where some Nerves, *nn*, are inserted therein from the Back-bone; and coming into the Belly, transmits two great Branches, *pp*, downwards, which makes other *Plexus* at *S T U u*, and from thence communicates Nerves to all the Intestines of the Belly, as may be seen in *W*, passing to the Bowels.

To conclude, there are none of the Entrails either in the Breast or Belly, but what receive Branches from the two Nerves we have here been describing; *viz.* the *Vagus* and the *Intercoſtalis*. Whoſoever deſires to ſee them minutely represented, may conſult the famous Works of Meſſieurs *Willis* and *Vieuſſens*; whoſe Figures from Branch to Branch, together with the Courſe of the Nerves in the Body, before they were Publiſhed, were compared and examined by another great Anatomist, being founded upon Experimental Diſſections of above 400 Bodies in the ſpace of fifteen Years.

One might here make infinite Remarks upon each Duſt, or Courſe, of theſe Nerves; upon their Inſertions into one another; upon the ſeveral Parts which receive their Nerves from the ſaid Branches;

ches; upon the *Plexus* that appears therein, and which consists of the Concurrence of many Nerves of a different Original; as at F, for instance, which is equally composed of the Sprigs of the *Parvagum* and *Intercostale*; to the end, that the Heart, which is thereby moved, might receive its Nervous Juice from the one, in case the other should fail: To say no more, can any Body imagine, that these Dispositions have been made without Wisdom?

SECT. IX. *Convictions from the foregoing Observations.*

I CANNOT forbear putting this one Question to a Man, that is still so unfortunate, as not to be able to discover from all these things, the Wisdom of his Creator; *viz.* Whether he can, without trembling, consider, that all this great Composition of the *Wandering* and *Intercostal* Nerves, by which his Heart, Lungs, Veins, Stomach, Guts, Liver, Kidneys, and every thing else, that contributes to the support of his precious Life, are moved, is performed entirely without his own Will and Concurrence? And, that there is scarce any thing else left to him, besides the command over those Nerves which serve for its external Functions; whilst, in the mean time, he is not able to continue one single Instant the Action of those Nerves by which he lives. Nor can the most obdurate *Atheist*, or the *strongest Mind* (as they love to call themselves) find here any Evation to satisfy his disturbed Conscience, that he is not absolutely in the Hands of another, upon whom his Life does continually depend; at the same time that he is forced to confess, from his own Experience, that all the Motions contributing thereto, are produced in him, without, and against his Will, by

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Nerves,

Nerves, whose Operations he can neither directly obstruct, nor promote.

If now this great Mover of all Things be Wise and Powerful, which appears undeniable from the Course and Operation of the Nerves, from their Disposition to perform their Functions, and from there absolute Necessity for Life, and the Preservation thereof; can the Atheist, without trembling, consider, that he, by thus imputing all to Chance, or something that acts without Wisdom and Knowledge, does as far as in him lies, rob God of his Attributes, and treads them under his Feet? Must not his own Conscience, foretell him that one time or another he will justly feel to his Misery and Confusion, this Power which entirely belongs to another, and which he finds absolutely necessary towards the Preservation of his own Being, and from which no Creature whatever can deliver him, any more than he can free himself; neither can he prevent his own Death whenever it shall please the great Preserver not to suffer the Machine of his Body continue any farther in Motion, and the Nerves, which do only perform their Functions, thro' his Influence, cease from the Exercise of the same.

SECT. X. *The unhappy Condition of the Atheists.*

How much more happy than is such a one, who from Contemplating the Disposition and Structure of his Nerves, and the Consequences thereof, has learned to know himself so far, as to be experimentally convinc'd, that his gracious Creator has caused all the Nerves which serve for the support of his Body, for the Motions of his Heart, Lungs, Stomach, &c. for the Circulation and Separation of his Humours and other Necessaries of Life, to operate for the respective Purposes, by an immediate

diate Power ; and not only without his Will, but even without his Knowledge, or any Perception thereof? And who having farther observed how many Nerves, by the wise Providence of his Maker, are still left for the moving of other Members, according to his own Discretion wholly ; I say, who is there, that after having seriously consider'd all these things, does not find himself obliged to use them all to the Honour and Glory only of his adorable Creator ?

And with how much more tranquility (to repeat it once again, since we can never reflect upon it too often) may such a Man observe, that this whole Frame of his Body, that both his Life and Death are absolutely in the Hands of so gracious a Creator, when he learns, from one kind of Nerves (by which he lives, and which being out of his Will and Power are only moved by his Preserver) that his constant Dependence is on him ; as he is again taught by another, the Operations whereof are in some Measure depending upon his own Will, to discharge his bounden Duty of Service and Gratitude to his bountiful Master ; I say how much more easy to himself, will the Life of such a Man be, than that of him who, against all the Proofs which demonstrate, after the most irrefragable Manner that there is a God, against all the Convictions, on one Hand, of the great Creator's Power over all that he has made, and which he continually and immediately preserves, does most imprudently deny him : And on the other Hand blasphemously employ his Tongue and the rest of his Members in despising that God, to whose Honour only he ought to use them ? Oh that the deplorable Atheist would consider and understand these Things rightly !

SECT. XI. *The Nerves of the Midriff.*

AND if this be not sufficient to convince every Man of the Views and Designs of a wise and merciful Creator, in the Disposition of the Nerves, let him cast his Eyes upon *Tab. IV. Fig. 7.* in which he will find the Representation of the Midriff, which we have caused to be drawn for this purpose only.

Now to say nothing of its circular Muscle A A, and another B, its tendinous Part C, the Passage D for the Gullet, and E for the *Vana Cava*; as also the Blood-Vessels that feed it, G H I; of which every Body that understands their Uses, can add a great deal more, in order to prove the wise Designs and Purposes of the great Creator: Can any one be so blind, who knowing how necessary it is, that the Motions of the Midriff shou'd depend upon our Will, when in extraordinary Breathing, in Singing, Speaking, and other Incidents, the same is requisite; observes here, that two Nerves K K, issuing out of the Nerves of the Neck (as they do from the *Medulla Spinalis*) and therefore do belong to those that are subject to our Will, are bestowed upon the said Midriff? And when he is moreover convinced, that it is no less necessary that the great Work of Respiration should be continually carried on, even whilst we sleep; and how inconvenient it would be, that whilst we are waking, if we happen to fix our Thoughts upon other Matters, we should be obliged every time to attend to the Business of Respiration, and to divert our Thoughts from all other Things to this alone: Can a Man, I say, without acknowledging the gracious Purpose of his Maker, observe that two other Nerves, L L, are communicated to the Midriff, which (as it happens also to the Bowels, Heart, &c.)

&c.) do continue the Motion thereof without our Concurrence, and when we least think of it, and for that reason take their Rise from the *Intercostal Nerves*, which are made for that Purpose?

SECT. XII. *The Nerves of the Intestinum Rectum.*

THE same may be observed, besides other Parts, in the *Intestinum Rectum*, which requires one Motion spontaneous and independent of our Will, in order to bring forwards that which is contained therein; and again, a second Motion, which is voluntary, in order to be exerted with the greater Force at the time of the Discharge.

The Words of the accurate Anatomist *Verheyen* are very remarkable upon this Occasion: *The Intestines have, among others, their Nerves of the great Plexus Nervosus in the Mesentery, and all of them are serviceable to the Motions performed without our Will. (Functiones involuntariæ.) But the Intestinum Rectum, and probably also that Part of the Gut that is immediately joining to it, has other Nerves from the lower Part of the Medulla Spinalis, by the help of which the Discharges of the Belly are performed, according to, and in consequence of our Will.*

SECT. XIII. *The Vasa Lymphatica.*

NOW as the Blood which goes thro' the Arteries to the Parts of the Body is brought back again thro' the Veins, the Enquirers into Nature have likewise asserted, and not without great probability, that the Humour which is separated from the Blood in the Veins, and which is communicated by the Nerves to all the Parts, is brought back also by another sort of Vessels (called the *Vasa Lymphatica*) to the Blood, and so performs as it were another Circulation.

Now whether this *Lympha*, or transparent Liquor, proceeds from the smallest Side Branches of the Arteries, in each of which at the same time a nervous Sprig discharges itself, we shall not hear farther examine, but refer such as desire to know it, to the second Work of Monsieur *Vieussens*: This is true at least, that these *Vasa Lymphatica* are observed to proceed from all the Parts of Creatures (the Brain excepted, that being yet doubtful) as likewise that the Course of their Liquor in *q q* (*Tab. I. Fig. 6.*) proceeds to the *Ductus Thoracicus* *O r r*, and so to the *Vena Subclavia*, *u x*, and other Places directly to the Veins; that they have innumerable little Valves, in order to prevent the Return of the said Liquor, and so appear like Links of little Chains *q q*; that they touch upon several Glands in their Passage, or proceed likewise from some. Those who desire to have any Notion of this Matter, may consult *Tab. IV. Fig. 8.* where it is shewn how these *Vasa Lymphatica* *L L L*, &c. coming out of the Kidneys *B B*, and other Parts of the Body, have a Communication with the Glands *F, G, H, I, K*, and discharge themselves into the Receptacle of the Chyle *D*, in order to carry their Liquor on to the Blood by the *Ductus Chylionus* *E*, which is here represented as cut off, and in the mean time (as we have said above) help to make a Stream for the Circulation of the Chyle.

Now how unknown soever may be the true Source or Origin of these Vessels, soasmuch as most of the Experiments have been made upon Beasts, and described from them, the Opportunities being very rare of opening Men so quickly after their Death, in order to discover these Vessels which do presently disappear, for which reason some principal Anatomists have endeavoured to shew there Course by injecting Quicksilver, prepared

pared for that Purpose, into them ; yet this at least is true, that they do discharge all their Liquor into the veinous Blood, and so render the aforementioned Service to the Chyle.

SECT. XIV. *The Glands.*

WE shall pass over the Disposition and Structure of the Glands, it being still subject to too many Differences and Disputes in the chiefest Matters, but which perhaps may furnish Posterity with new Matter to convince the Unbelievers, of the Wisdom of their Creator ; however it appears in the mean time plain enough, that they cannot attribute it to *meer Chance*, or *ignorant Causes*, that the said Glands are useful to so many, if not to all the Separations of Juices ; and that this wonderful and as yet unknown Effect, is produced in their Bodies. *viz.* That the Blood (which in it self is in a manner insipid) being brought into the Glands by its Vessels, the Humours that are separated from it in those Glands, are thereupon impregnated with so many different Tasts and Properties. Thus that which is separated in the Kidneys is Salt, as are likewise the *Tears* and the *Sweat*, which proceed from the Glands of the Eyes, or come out of the Pores of the Skin ; from the Liver there issues a bitter Gall ; from the Glands of the Breasts of Females, a sweet Milk ; from the *Glandula Salivales*, Spittle, &c.

Now every Body knows, that upon the Obstruction or Cessation of any of these Humours, grievous Sickneses and Death itself does sometimes follow ; and that almost all of 'em, how different soever their Nature be, are absolutely necessary to Health or Life. The Nerves likewise, and the Arteries, which carry the Blood and the Nervous Juices thereto, or discharge themselves therein ; the Veins and Lymphatick Vessels which bring
back

back the Blood and *Lympha*, or what is separated from thence, and which contribute to a Passage or Way for the separated Juices, where they can be useful in so many particular Vessels already discovered; I say, all these things do abundantly instruct us, that each of 'em are formed for a particular End, and are therefore placed exactly where they can be most serviceable; the rather, since Anatomists have discovered (See *Vieussens* in 8vo, p. 238.) that altho' there is little Motion or Sensation in them, yet, in respect of their Bigness, more Nerves are found in them, than in any other Part of the Body,

SECT. XV. *The Membranes.*

MUCH might be here said about the Membranes, and which would powerfully support our Design, especially if we would here propose all the modern Discoveries that seem to be only in their *Embryo*, and have not yet attained their full Perfection; this is certain, that they have the following Uses:

1. That they serve to cloath or cover some Parts, as may be observed of the *Pleura* in the Breast, and of the *Peritonæum* in the Belly.

2. To form Tubes and Vessels, as in the Blood, and Lymphatick Vessels and Intestines.

3. To join or fasten some Parts together; thus are the Intestines fastened to each other by the Mesentery, and both together to the Back.

4. To divide Cavities into more Parts; thus the *Mediaſtinum* divides the Breast into two Spaces, under which Head we may likewise reduce the Membranous Valves in the Heart, Veins, Lymphatick Vessels, &c.

5. Not to reckon that they are by many esteemed to be true Instruments of Feeling, and perhaps of other external Senses.

6. There

6. There is yet a greater Service performed by them, *viz.* That many of 'em consist of muscular Fibres, which by their Contraction or Squeezing, when they make Tubes or other Cavities, are proper to protrude that which is included in those Membranes ; as we see it happens in the Stomach, Guts, Bladder, Arteries, and the like.

SECT. XVI. *The Dura Mater, or thick Membrane of the Brain,*

MONSIEUR *Pacchionus* shews, that according to *Anatomical* and *Practical Observations*, the thick Membrane of the Brain, commonly called the *Dura Mater*, has the same Property of protruding the Humour separated in the Brain into the Nerves ; and since this Membrane does invest all the Branches of the Nerves, how many soever they be, he thinks it is very probable that by a Contraction of its Fibres (like that of the *Peristaltick Motion*, which happens in the Intestines) the Humour is driven forth into the Nerves ; I leave this Matter to farther Enquiry ; but if one may here mention that which seems very likely concerning it, I should think, that unless somewhat of that Nature did occasion the Protrusion of the Nervous Juice, such a Power or Faculty could not be deduced only from the Motion of the Heart ; forasmuch as the Matter of which the *Medulla Spinalis* and the Nerves are composed, does not seem proper to afford a swift and ready Passage to such a tough and Turpentine-like Humour, as the famous *Malpighi* describes it to be. Moreover, it seems to be a necessary Consequence, that in case the Heart were the only, or chief Cause of the Nervous Juice, a Nerve being tied or bound, as is usual in Arteries and Veins, would swell up against the Band, which many who have made this Experiment complain

complain does not happen ; but if the Contraction of the *Dur'a Mater*, which encompasses the Nerves, does, without any visible Assistance from the Heart, alone protrude this Humour, every Body must own that this *Peristaltick Motion*, by the Compression of a String or Band, would be forc'd to cease ; whereupon, that which we experience would follow, *viz.* that the Nerves would not be able to swell and expand themselves by the protruded Matter against the Band.

For a further clearing of this Matter, I could have added some Practicā Cases, which, without the Hypothesis of such a Motion in the Nervous Membranes, would seem unintelligible, and yet, being handled upon this Foundation, meet with the desired Success, after having tried several other Means in vain. But this is not a time to speak of these Things here ; let every one consider and reflect by himself, whether upon seeing the known and undeniable Uses of the Membranes, he must not acknowledge and be convinced of the Wisdom of his Creator.

SECT. XVII. *The Flexibility of the Membranes.*

To speak something of this Matter : Forasmuch as it was necessary for the Support of Life, that the Blood and Nervous Juice should be carried to all the Parts of the Body, and brought back again, it was no less necessary that Vessels, such as the Arteries, Veins, Nerves, and those belonging to the *Lympha*, should be formed for that Purpose : But since, besides this, the Body was to be moved, and that therefore Inflections and Angles were to be made in its Joints, it seemed requisite that these Tubes ought likewise to be flexible, to to the end that (for Instance) the Arteries in the Arm and Hand might serve for a Passage to the Blood,

Blood, as well when they were bent at the Elbow or Fingers, (at which time so many Angles and Inflections are produced,) as when the same Arm or Hand being stretched out, the said Tubes were likewise extended in right Lines.

Now let every Man ask himself, after having observ'd the aforesaid Matters, and discovered the Tubes adapted to all these Uses, whether he can be satisfy'd in ascribing 'em barely to uncertain and ignorant Causes? But on the contrary, whether the greatest Artificer in the World must not have employ'd much Study and Thought to adapt 'em all to several Ends? And when he sees Vessels compos'd of such thick and strong Membranes, and of the utmost Flexibility at the same time, not only for forming their Offices as Receptacles, but also pos'd continually to protrude what they contain; can he pretend that they are form'd without Wisdom? Nay, must he not own himself the most unreasonable of all Men? being obliged to confess that no small Wisdom is requisite towards the Invention of the same; and yet when he sees them invented and fram'd after the best manner, will perversly maintain, that it all happens without a wise Contrivance or Direction.

We shall pass by other Remarks concerning the above-mentioned Glands and Membranes, having dwelt long enough already upon 'em; as also all that might have been added farther upon many other Matters, such as the Ligaments or Bands by which the Bones are joined together; of the Fat, Skin, *Cuticula*, and the like; those who have a Mind to examine into what is already discovered thereupon, will find Cause enough to extol the Wisdom and Goodness of the Creator.



CONTEMPLATION X.

*Of the Muscles.*SECT. I. *The Transition to the Muscles.*

NOW in case that the foregoing should not appear sufficient to convince every Man fully, and entirely, of the great Ends of his Creator, and of the most wise Manner of executing the same; (tho' not hardly to be supposed, of such as have thoroughly comprehended what we have already represented to them thereof) yet, at least, this great Truth will appear to be placed beyond the Reach of all Doubting, by the single Enquiry only into the wonderful Composition of the Muscles of a humane Body; which Muscles are, in a manner, the Instruments of all its Motions. And in case any Body should view, with an understanding Eye, the Insertion, or Fastening of the same to the Bones (which are likewise so exactly adapted for the making of Limbs and Joynts, whereby Motion may proceed without Interruption) their wonderful Contexture, and the amazing Power and Strength communicated to them, tho' consisting of such exceeding fine and slender Fibres or Threads; I say, whoever contemplates any of these Particulars, must needs acknowledge in all of 'em, the Hand of a great and mighty, wise and good Creator; the rather, because he has an Example thereof in the greatest Philosophers and Mathematicians, whom the Contemplation of these Wonders,

Wonders, and the Enquiry into the Wisdom that shines out of them, have often compelled to acknowledge the Glory of GOD in these his Works. For one Instance, amongst a great many others, one need only peruse the Dedication of that Book, that Monsieur *Borelli* published, about the *Motion of Animals*.

SECT. II. *Of the Muscles in General.*

Now not to ask whether any Body, that understands never so little the Structure of Muscles, could believe, that those which move the Tongue, or the Hands of a Man (to mention no more of 'em) are made without *Design*, without *Wisdom*, and by *Chance* only; and that all the so necessary and useful Functions, performed by them in the Bodies of Men, are produced by ignorant Causes: Can it be imagined, that the Power and Goodness of our great Creator does so far extend itself towards us, that the Muscles in a Man's Foot have been adapted by him, to serve upon occasion, in the stead of Hands? And yet, as strange as this may seem to be, we have seen, not long since, a Man, who being born without Arms, could use his Feet almost for all Purposes, and among others, write a fine *Italian* Character with the same, as fast and as accurately, as another good Writer was able to do with his Fingers; to say nothing of many other of his Motions, such as shuffling of Cards, and playing therewith, and managing a good Number of them so dextrously, that he could not have done it better if he had the use of both his Hands: Now in case those Muscles that move the Feet, had not been of proper Structure for the like Purposes, it would have been impossible that he could have performed all this with his Feet.

And are we not taught by the smallest light of Reason, that when we see such a wonderful Machine,

Machine, compos'd of such Joynts, as we only use for Supports of our Body in Walking, Running, and other little Purposes, we are bound to thank our Maker, who has contriv'd the Structure of our Muscles, that are yet so much more useful and beneficial than any Body, even the very greatest Philosopher, could ever have believed, were it not that Experience has render'd it so obvious even to the meanest Capacities.

SECT. III. *The Description of the Muscles.*

HOWEVER, to enquire a little more closely into the Structure and Disposition of the Muscles, and to represent the overflowing Wisdom of our adorable Creator, by some few Observations upon the same, let us contemplate *Tab. V. Fig. 1. 2, 3.* which will give us a Sketch of the external Structure of some of the Muscles, the great and principal Instruments of all our Motions, and by which alone we exert our Strength.

1. A Muscle then (not to mention here its Artery, Vein, Nerve, and Lymphatick-Vessels, which are represented in *Tab. V. Fig. 1. a b c* tied together) does consist of a Number of fleshy Fibres or Threads B, running Parallel mostly, and at equal Distance from each other, and fasten'd at Top and Bottom to a tough Body, called a Tendon, A and C.

Across these fleshy Fibres B, there run others E F, which are likewise tendinous, nervous, or membranous; but as slender as some of 'em are, they are all very tough, and not easy to be broken, and are regularly interwoven with fleshy Fibres.

Now in case the Tendon A, the Fibres whereof are here shewn to be a little separated from each other, be fasten'd to a Bone that is unmoveable; and

fronting the

Fig.



Fig.



and the other C, to one that is movable, and can yield to the bending of its Joynt ; and afterwards each of these muscular Threads B, are contracted, or render'd shorter by any Force, be it what it will ; it is plain, that the Tendon C, will draw the Bone that can follow, and to which it is fasten'd, towards the other Tendon A, and so will bend the Joynt that lies between A and C.

The Anatomists are wont to call the Tendon A, which is fasten'd to the immovable Bone, and towards which the Motion is made, the *Head* of the Muscle ; and the other C, fasten'd to the movable Part, the *Tail* ; and the fleshy Threads B, with the tranverse ones F E, the *Belly* of the Muscle.

SECT. IV. *The Strength of the Muscles consists in their many Fibres.*

2. It appears from hence, that the more Fibres there are in B, or the Belly of the Muscle, which being contracted do draw, the stronger will be the Action, of such a Muscle, which is also found true by Experience.

SECT. V. *Double Muscles.*

3. Now to the end that a Muscle may exert greater Force, it will be necessary, that it should consist of a greater Number of Fibres B, which may cause it to encrease very much in Thickness, and so fill that Place, in which other Muscles serving for other Purposes, might have been lodged.

Can any Body then, without Amazement, reflect upon the most ingenious Manner which it has pleased the wise and gracious Creator to use, so to dispose many more Fibres in the same Space, in order to make the Muscle so much the Stronger, that there shall not be requir'd much more Room to place those Fibres ? viz. by leaving to a kind of Muscles, that are necessary in producing a stronger Motion

than others, the usual Breadth or Space, which they are to fill after such a manner as we see in *Tab. V. Fig. 2.* in which *A B C* is the Head of the Muscle or Tendon, fasten'd immovably at *A*, and represented in this Figure as cut off; *E D* is the Tail of the other Tendon, that draws the Joint to itself; and between both of them are two artful Rows of Fibres *F* and *G*, being fasten'd to the Head *A B C*, and running obliquely to the Tail *E D*, in which they are inserted, from whence it appears, that these two Rows of muscular Fibres, *F* and *G*, being forcibly contracted, the Tendon *E D*, and the Bone fasten'd to it, which is moveable, must be drawn towards *A*, with this Advantage over that which was shewn before, in *Tab. V. Fig. 1.* that here (*Tab. V. Fig. 2.*) many more Fibres, as *F* and *G*, can be put in Action in the same Space, whilst they run after this manner obliquely, as it were across, than when they were extended, as in the former *Fig. 1.* directly only, and at equal Distances from each other.

SECT. VI. *Muscles yet more doubled.*

WE may observe again, in *Tab. V. Fig. 3.* that these muscular Threads are, after a wonderful manner, upon some Occasions, much more doubled: *A* is the Head, and *B* the Tail of the Muscle, the which last *B*, by two tendinous Branches that are extended towards *A*, gives an opportunity for the ranging a much greater Number of fleshy Fibres in such an exact Order; so that the Fibres *C* and *D*, being fasten'd to *G A H*, or the Head of the Muscle, (which is supposed immoveable.) when they are contracted in their Length by any Force, do each of them draw their Branch *F*, and these two Branches *F* and *F*, draw the Tendon *B*, and whatever is fasten'd thereto, and is moveable towards *A*, which, if it were to be performed by Fibres running

ning directly or streight from A to B, as in *Tab. V. Fig. 1.* would, by the greater Number of them, compose a Muscle almost as thick as this Muscle (*Tab. V. Fig. 3.*) is long : If what we have here said, does not set this Matter in so clear a Light as to make it fully understood, the Reader may consult *the Demonstration of the Force of the Muscles* SECT. XVII.

Now will any rational Man suppose, that all this is so nicely adapted to such great Purposes by Chance, or ignorant Causes? And can he discover herein no Wisdom of the Creator? When at the same time, unless he would be accounted a Fool, or Mad, he durst not deny, that all the Parts of a great Rammer for driving Piles, at which so many Men are obliged to draw with Ropes, is form'd without Wisdom and Design.

SECT. VII. *The Muscles of the Fingers.*

4. FOR farther Conviction, let us make one only Remark upon some of the Muscles that bend the Fingers; we will therefore consider the Muscle A B (*Tab. V. Fig. 4.*) as it is fasten'd with its Head or upper Tendon near the Elbow K, whose moving Threads or fleshy Fibres extending themselves from B to A, do compose the lower Tendon C, and this consisting of four Parts, transmits a Branch to each of the remotest Joints of the Fingers, wherein it is inserted at D; now when the fleshy Fibres A B, are contracted, the Muscle being immoveable at K, it is easy to observe, that the third Joint of the Fingers D D D, is thereby drawn towards B, and all the Fingers inflected; the rather, if you suppose farther, that the Muscle G F (which is represented here out of its Place, and lying above A B) is likewise contracted in its Fibres F G, and by its four Tendons, G E, draws over forwards the second Joint of the four Fingers.

Now let every one ask himself, whether he can suppose, that it is by meer Chance, *First*, that these Muscles A B, and G F, which bend the extreamest Joints of the Fingers, are placed so far above the Hand, and even as high as the Arm, and yet extend themselves by their long Tendons C D and G F to those Joints which they are to move, since, if they had lain in the Hand itself, they would have render'd it very unfit for an accurate easy handling of Things? Forasmuch, as these Muscles being obliged to exert a great Force, do require many fleshy Fibres, which, when they were contracted and put into Action, would cause the Hand to swell to a great Thickness.

For, that these, and other Muscles, such as those described by A B, do upon their Contraction require a greater Thickness, may appear to every one, who upon closing with some Force, one of his Hands and turning it into a Fist, does with the other Hand span his Arm below the Elbow; in doing which, he will remarkably feel the Muscles that lie there to be swelled: Which Thickness, if it were continually produced by such great Muscles as lie in the Hand, it is plain, would, upon many Occasions, embarrass it the Exercise of its Function

Secondly, Whether he must not acknowledge, that it is a Contrivance beyond the Power of an *Ignorant Cause*, that the Tendons G E, of the Muscle F G, do make a kind of Door or Opening at E? by which Means the Tendons C D of the Muscle A B, pass like a Thread thro' the Eye of a Needle, in order to hinder these last in the numerous Motions which the Fingers make upon many Occasions from being disorder'd by Dislocation or other Accidents; or at least, that the Motions of all the Tendons, lying near or upon each other, may not be so loose and uncertain.

This d'y

Thirdly, Because there would be Danger upon the Contraction of the Muscle A B, that the Tendons C D, which go to all the Joynts of the Fingers should recede from the same, when they were bent upwards, and occasion several Inconveniences, by stretching the Skin too much: Can any one see, that each of these Tendons is encompassed with a kind of membranous and very strong Sheath, which, without obstructing their Motion at all, makes it remain fast to the Bones of the Fingers; not to mention the great Band just above the Hand, which encircles the Arm in that Place like a Ring, and at once binds together all the Tendons of those Muscles that go to the utmost Parts of the Fingers, preventing them upon great Inflections from receding too far from their proper Places; I say, can any one see all this, without acknowledging the Designs of a great Creator;

SECT. VIII. *Of the Joynts.*

GOD has been pleas'd to manifest his Power and Glory after very different and surprizing Ways, in endowing the Bodies of Men and other Animals with many Kinds of Motions.

In order to prove the same, he who would be convinced of the greatest and most important Truths, and of the Attributes of his adorable Creator, need but enquire a little more narrowly into the Instruments that serve for such Motions? For which purpose it may be of use to unexperienced Persons, if we set before their Eyes a rough and general View of the Structure of the *Joynts* in this Place; referring the Particulars to the Place where we shall treat about the *Bones*, &c.

The Joynts of a Man necessary to produce the Motions between the two Bones C D E, and I B (*Tab. V. Fig. 5.*) are most commonly of the following Structure; in the first, C G E, there is found

a larger or smaller Cavity C D E, in which the protuberant Part, C D E F, or I of the other Bone is fasten'd after such a manner, that they can both turn and move in each other: Now in case this protuberant Part, C D E F A, being spherical, or round, is exactly adapted to the Cavity C D E, it is easy to see, that the Bone B A may be moved at Pleasure upwards or downwards, and on either Side; but in case the said Part, I, were not perfectly a Part of a Sphere, but round and flat, like a Piece of a Wheel, and then inserted into its Cavity, it is plain, that the Bone B A might be moved upwards and downwards, but not sideways.

A Motion analogous to the former, may be observed in the Shoulder or Hip; and to the latter in the Elbow or Knee, some little Circumstances excepted, which in the main, do not alter the Case, but serve for other Improvements.

Now can the best Mechanist in the World compose or put together any Joints after another manner, whereby so great a Force may be produced, with so much Conveniency, and so little Danger of being disorder'd by common Motions? Yea, we know that if one Bone turned upon the other with a sharp Point, in using any Force or Violence, it might perfectly miss its *Fulcrum* or Support in many Accidents, and the Point run the Risk of being broken, or at least disjointed: It would likewise have been impossible, after the same manner, for a Bone of any common thickness, to make so acute an Angle as the Elbow does with the Bone of the Arm; nor could the two Bones be in such a Position, with respect to each other, and parallel with the length of a Man, as the whole Arm is, when extended downwards on the side of the Body, or upwards on the side of the Head. In other Forms or Modes of Joints, besides those which appear in Animals, other Inconveniencies will result from them.

To

To prevent all which, what safer Method can be made use of to produce the Motion of two Bones, than that which is represented in *Tab. V. Fig. 5.* not by the extream Point thereof, which might be easily broken or dislocated, but by a Centre I, which you must suppose to be in the middle of the spherical Protuberance, C D E F A, of the Bone A B, or if it be Cyindricall, about the Line, which runs length-wise thro' the Centre thereof, and of which I is the extream Point, as we see it happens in our Joints.

I have dwelt the longer upon these Matters, because if ever this Book should happen to fall into the Hands of such a Philosopher, who cannot be convinced from the Structure of his Body, of the Wisdom of his Maker he might hereby be excited to employ all his Understanding, Philosophy, Mathematicks, and what other Learning, or Talents he may have acquir'd, and to try whether, besides this Structure of the Joints, he can find out any other Machine or Contrivance that may be so very Serviceable, and of so little Danger, as that which his great and wise Creator has already form'd in his Body; and if he would but take the Pains of consulting the greatest Mathematicians on this Occasion (*Borelli* for Instance, *SECT. IX.*) he will soon find how readily they acknowledge herein the Wisdom of the Creator. Wherefore, in Case he be not convinced by all this, but continue to think that such a Structure, which cannot be mended, neither by his own, nor by the Skill of all the Men in the World besides, in order to be made subservient to these Purposes, has yet acquir'd its Existence by meer Chance; to what shall we ascribe the Cause of such desperate Notions, but either to his Ignorance, which suffers him not to understand these Things; or to a secret and dreadful Judgment, proceeding from

the Wrath of God, who being at last weary of tolerating such blasphemous Opinions in his Creatures, permits him, in the midst of Light to persevere in this miserable and fatal Darknesh. But to proceed.

SECT. IX. *The Insertion of the Tendons,*

SUPPOSE A B, and F G, in *Tab. V. Fig. 6.* to be two Bones joyned together, which make a Joint at A F; now if one would bend the Bone A B, at H, and for that purpose, only make use of the Draught and Contraction of the Muscle D R E, which is immoveably fasten'd to D in the same manner as one moves the lowest Bone of the Arm, by bending it in the Joint of the Elbow towards the uppermost Bone or *Os Humeri*: Let us suppose first, that the Tendon of this Muscle is inserted at E, or close to the Hand in the extream Part of the Bone A B, we may then easily bend these two Bones upon contracting the Muscle D E, at the Joint A F: But if the Bone A B, be brought to A H, in such case the Muscle D E must be contracted or shorten'd to M D; but if one proceed farther, in order to cause the Part H to approach yet nearer to D, by the same Muscle, the whole Muscle D E, which is now shortn'd to D M, will in a Manner lose its Length, and be rolled up in a Ball or globular Figure at the Shoulder D: Besides, that when the Bone A B is raised up to A H, the Skin must have so much Space or Room as to cover the whole Triangle A H D, unless the Muscle were naked and loose from the Arm, as is represented in this Figure,

Now if this should happen in many Parts of the Body, and that more room should be taken up in the Skin, by other Muscles that are larger, and planted in the Bone after the same manner; and so make larger Balls or Spherical Figures in the Places

Places where, by their Contraction, they are rolled up together, the Body would lose its Figure at every Motion by such Expansion of the Skin, and upon the ceasing thereof and Extension of the Muscles lengthwise again, the Consequence would be, that the expanded Skin would hang upon the Body like a Bag full of Pleats or Wrinkles, to the end that it might have room enough in its subsequent Motions.

'Tis true, that it seems as if this manner of Infertion might have been passed by, to preserve the beautiful and noble Structure of a humane Body, and a Band or Ligament placed at R, to obviate the receding of the Muscle from the Bone: So that the Body of the Muscle it self being then extended no farther than to D R, a long Tendon E R, need only be stretched to E, and likewise fasten'd to the Joint at its Inflection by the Ligament R, as is shewn to happen in *Tab. V. Fig. 4.* where there was a particular occasion for it, namely, that the Hand might not be burdened with too much Flesh.

But in such a case, it cannot also be denied, that if all the Tendons were fasten'd to the extrem Part E, of the Bone A B (*Tab. V. Fig. 6.*) notwithstanding that they were kept down by the Ligament R, yet, by reason of their Length, they would fill a much greater Part of the Body, and take up more room than they now do, which would not only be unnecessary, but would likewise displace some other Part.

Not to mention that in this Structure the Tendon R E, running either parallel with both the Bones, G F and A B, or making a very small and acute Angle at E, with the Bone A B as long as the Angle remains so small, could not be able to exert much Force in order to raise the Bone, tho' drawn with great Violence. That it falls out
so,

so, in oblique Draughts, the Mechanists know very well; and the same will easily appear by an Experiment in *Tab. V. Fig. 7.* if at the end of the Lever *BC*, which can turn about an Axis in *C*, a Force *A* draws in the oblique Line *BA*, it will not heave up so easily the same Beam, to which a Weight *D* is hanging, as when this Force draws by a less Obliquity (in the Line *BE*,) the Beam and Weight upwards. Wherefore the Muscle (*Tab. V. Fig. 6.*) working in the Angle *DMC*, on the Bone in *H*, will perhaps, with the same Force, do eight or ten Times more than at the beginning with the Angle *DEC*.

With how much more Advantage than has the great Creator of Mankind been pleased to direct this Insertion of the Tendons in the Bones, after so wise a Manner, that not only all these Inconveniencies are thereby prevented, but likewise the Spaces, which would be otherwise filled by the excessive Lengths of so greatly extended Tendons, may with much Ease be employed in receiving other Parts that serve for farther Purposes?

For this End it has pleased him in his Wisdom to place little Eminences at the extrem Parts of the Bones, and thereby to render them thicker and stronger in that Part, and to insert the Tendons near or in the said Eminences, or close to the Joints in the following Manner

Let *AB* and *FG* (*Tab. V. Fig. 8.*) be two Bones, making together a Joint at *AFG*, which is moveable at the Point *C*, so that both of 'em at their Extremities *IK* *AF* are globular, and thicker than their Tubes: Now the Muscle *DEKI* is inserted at *I*, close to the biggest Knob of the Bone *BA*; so that it runs about the Eminency *KI*, like a Rope in a Pulley, if we may be allowed to give such a coarse Idea of it.

SECT. X. *This Insertion of the Tendons prevents all Inconveniencies.*

WE need not then take much Pains to shew, that by such a Method all the aforementioned Inconveniencies are removed; forasmuch as, *First* the Tendon being inserted at C (*Tab. V. Fig. 6.*) and not at E, when contracted towards D, cannot make such a Triangle as M C D, and consequently don't stand in need of so much Room in the Skin for its Motion. *Secondly*, the Muscle D E K I (*Tab. V. Fig. 8.*) being inserted in or near the Thickness of the Bone, in order to produce a great Velocity at B, the extream Part of the Bone A B, such as from B to M; it needs only inflect the Point I, in a very short Segment of a Circle to K; for which Reason likewise the Muscle requires very small Contraction; nor is it requisite that the whole Length should be rolled up in a globular Figure; and thus, the Muscle being grown but very little thicker by so small a Contraction, the Body loses nothing of its Figure and Beauty; whereas otherwise, if the Tendon were inserted in the extream Part of the Bone (as at E, *Tab. V. Fig. 6.*) the said Body, supposing the same should happen in all its Parts, would for both these Reasons become very monstrous. *Thirdly*, We may likewise see here, that the whole Length (*Tab. V. Fig. 8.*) remains free from I to B, without being filled by the Tendon of this Muscle D E K I, and so there is a Place left for other Parts and other Uses. *Fourthly*, The Mathematicians know, that when the Muscle at K, fix'd to the Knob or Thickness of the Bone F A I K, performs its Function after the manner of a Pulley; the Line K C, which extends itself from the Centre C to K, on account of the Roundness of the said Knob, is always nearly of an equal Length; and therefore when the Muscle is contracted

tracted with equal Force, it always exerts the same Strength when it proceeds to lift up the Bone A B ; in which, it has been already shewn, at *Tab. V. VI, VII*, there would have been a great Inequality on account of the changing the Obliquity of the Angles, had it not been for this manner of Insertion.

SECT. XI. *A Muscle exerts a greater Force against a smaller Weight.*

IT is true that the Muscle DK (*Tab. V. Fig. 8.*) acting on a shorter Arm of a Leaver C K, and an opposite Weight at a longer Arm C B, the Power of the Muscle must be so much greater than that of the Weight ; and that it seems to contradict the Custom of Men, in making Instruments to raise up a greater with a smaller Force, since all their late Discoveries in Mechanicks, in the several Engines for Motion, such as Balances, Leavers, Pulleys, Wheels, inclin'd Plains, and Screws, &c. seem to have a contrary View, that is to say, by a smaller Power to move a greater Weight ; which Weight they therefore hang upon the shortest Arm.

But no Body will be able to deny, *First*, That in the Motion of the Muscles, all the Inconveniencies already enumerated, are avoided by this Disposition, which requires a greater Force in the Muscles.

Secondly, That in the common Mechanical Instruments, where a greater Weight is raised by a smaller Power or Force, the Motion of the Weight is always much slower than that of the Power ; and that if it be required to raise the same Weight with greater Velocity or Quickness the readiest Way ; the Power must be apply'd to the shorter Arm, and the same proportionably encreased in Greatness only, without being oblig'd scarcely to augment the Velocity thereof in this Case, which would otherwise be necessary.

SECT.

SECT. XII. *The Reason why a greater Force is made Use of by the Muscles against a smaller Weight.*

IF this Matter does not appear yet clear enough to every one, let them imagine that the Muscle **DKI** (*Tab. V. Fig. 8.*) does by its Force move the Knob of the Bone **KIAF** from **V** to **K**, by which Means the Point **B** is at the same Time raised to **M**, and therefore acquires so much more Velocity than the Point **V** or **I**, upon which the Force of the Muscle operates, as the Arc **BM**, or the Arm **BC**, is so many Times longer than the Arc **KV**, or the Arm **KC**; and therefore, the Muscle itself will be but a very little contracted, as it is plain to every one that considers this Matter.

SECT. XIII. *Convictions from the foregoing Observations.*

Now can any Body that judges impartially forbear observing here, that the great Force of the Muscles which is required in exerting their Motions in the abovementioned manner, is so far from a Diminution of the Wisdom of the Creator, that, on the contrary, it ought to be an Occasion of Thankfulness to every reasonable Person; forasmuch as their gracious Creator has been pleased, in augmenting the Force of the Muscles, to cause them to operate in so easy and almost insensible a Manner, with such little Contractions, and yet at the same Time to make them produce the Motions of the Limbs upon which they act, with such an unequally greater Swiftmess?

And can any unhappy Atheist pretend, that he sees neither Wisdom nor Goodness in all this? And will he yet ascribe it to ignorant or accidental Causes? Every Body that judges impartially, must undoubtedly think him very malicious, or stark blind

blind. Much more must an inconstant and wavering Mind be irrefragably convinced hereby ; not only that a wise Contrivance of a Workman is requisite for these Purposes: But even that a great Power, yea, a divine Power, surpassing all that is humane, shines out here with the utmost Lustre.

SECT. XIV. *The very great Strength of the Muscles.*

Ask an Atheist, ask a Sceptick, ask a great Mathematician and Philosopher, ask all Men without Distinction, and let them say if they can, after what manner in such tender Threads of Muscles, as are those of which the Flesh of Men and Beasts is made up, a Faculty is lodged, by which, upon their contracting themselves, such a surprising Force can be produced, as is exerted by them in their Motion.

And let no Body think that we are speaking hyperbolically to magnify the Matter, or to excite their Astonishment: For,

First, Can any one believe, if it had not been demonstrated by that great Mathematician *Borelli*, *Par.* 87, 88, and 127, that when a Man lifts up with his Mouth a Weight of near two hundred Pound with a Rope fasten'd to the Jaw-Teeth (which, according to him, has been done even as far as to three hundred Weight) that the Muscles named the *Temporalis* and the *Masseter*, with which People chew, and which perform this Work, do exert a Force of above 15000 Pound Weight?

Secondly, Can any one see without Astonishment, that when the Weight R (*Tab. V. Fig. 9.*) of fifty five Pound is held up in *Equilibrio* by the Elbow B, of the Arm AB, the Muscle named *Deltoides* DC, which only raises the Arm in this Position, exerts a Force of above 60000 Pound? See the said *Borelli*, *Par.* 124, at the End.

Thirdly,

Thirdly, If any one hanging his Arm directly downwards, lifts a Weight of twenty Pound, with the third or last Joint of his Thumb, can he learn without Amazement, that the Muscle which bends the Thumb, and bears that Weight, uses a Force of about 3000 Pound? He that doubts of it, may consult the abovementioned *Borelli*, *Par.* 86, 126.

But, *Fourthly*, He who sees that the *Musculi Glutai*, which together compose the greatest Part of the Buttock, and move the same about the Top of the Hip-bone backwards, do exert a Force of about 300,000 Pound, when they raise a Weight of 65 Pounds, by extending horizontally the Bones of the Leg and Thigh, according to the Experiment of *Borelli*, *Par.* 125. I say once again, Whoever sees and understands this, must needs admire the Power of his great Creator, that he has endow'd our Muscles with so vast a Strength. See *Borelli*, *Par.* 125.

Especially, if we here add, *Fifthly*, That calculating all the Forces of the Muscles that are exerted, when a Man, standing upon his Feet, does only leap or spring upwards the Height of about two Foot; if the Weight of such a Man be a hundred and fifty Pound, the Muscles in that Action will exert above 2000 Times more Force, that is to say, about 300000 Pounds. *Borelli*, *par.* 176, computes it yet higher.

And, *Sixthly*, That the Heart at each Pulse or Contraction, by which it protrudes the Blood out of the Arteries into the Veins, exerts a Force of above 100,000 Pounds; see the same *Borelli*, *Par.* 76. *p.* 11. we chuse rather to speak of these Matters in round Numbers, than exactly to follow his Calculations, (which are every where larger) that we may prevent any Cavilling in these surprising and wonderful Matters.

SECT. XV. *Convictions from the foregoing Observations*

YEA, if the Force of the Muscles were really much smaller, ought we not to stand amaz'd at it, whilst we thus discover in our Bodies the Divine Power of our Creator, producing such strange Effects with a Matter so fine and tender as the Flesh of an Animal, contriving and disposing them in so narrow a Compass, and adapting 'em to such regular Ends? When we see the Joints form'd, and their Motions maintain'd by perpetual Fountains of Oyl and Water (of which more hereafter) to preserve them smooth and supple? And above all, when we see such surprizing Force in many Muscles so readily obeying his Will, that is to say, moving and resting as we please; and others again, moving spontaneously and involuntarily; and farther, a Faculty or Power placed in the Muscles themselves, whereby, tho' their Motion ceases, they are contracted or shorten'd; and this Power balanced by a contrary or opposite one, in such a Manner, that the Parts of the Body may also keep their just Proportions, without any Concurrence on our Side; as, for Instance, the Mouth is preserv'd and held exactly in the middle of the Face, by two Muscles drawing against, and balancing each other; this is very obvious, when one of those Muscles having lost its Force by any Disease, the other shall convulse or draw the Mouth awry, and thereby the Face will be depriv'd of its beautiful Regularity and Uniformity.

To conclude this whole Matter, Can any one ascribe all this to Chance, or one that works without knowing that he makes any Thing, and this in particular? And does not this prodigious Force which the Muscles exert, raise his Thoughts to an Almighty Workman; and the Direction of them,

to infinite Wisdom and Goodness? And can he observe, that almost inexpressible Force, which his Body would exert, if all the Muscles thereof should put forth all their Strength at once, without being struck with Amazement at the same.

He that cannot yet, in the Contemplation of his own Body, discover a God, how unhappy, how deplorable, must he be?

SECT. XVI. *Transition to the Demonstration of the Force of the Muscles.*

WHILST I am writing this, it is objected to me by a certain learned Person, that what has been said about the Force of the Muscles, will not appear to all Readers so strange as really incredible; since it will not easily be admitted by any one without further Proof, that a Power of so many thousand, yea, hundreds of thousand Pounds, can be exerted by the Flesh of a human Body: Wherefore that we may not give Occasion to *Atheists* and *Scepticks* to think that we rather affect to say something here that is surprizing and uncommon, than what is true; it seem'd necessary to shew in some manner, the Grounds of our Assertions: He own'd indeed, that I had referr'd those who doubted, to *Borelli* and his learned Work, but that the same could not well be read and understood, but by experienced Mathematicians; but forasmuch as all of them did not entirely agree in their Investigations of Nature, the unhappy Philosophers whom we endeavour to confute, might pretend from thence to avoid the Force of this plain Proof of a great, powerful, wise, and gracious God.

For which Reason, he added, if it could conveniently be brought about, it would be of great Use to demonstrate this Force of the Muscles, which so far surpasses all Belief, upon such Grounds as

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might easily be apprehended by a sensible Reader, tho' not well vers'd in Mathematical Sciences.

This Consideration has prevail'd on me to insert here the following short Digression, which may help to give those that are unexperienced, a clearer Conception of what *Borelli* has discover'd in this Matter, in which I have therefore represented the greatness of the Force of the Muscles as plain as I can, without adding those Mathematical Demonstrations, which are so tedious to some, and so unintelligible to others; requiring nothing more of our Reader, but that, besides the Knowledge of a few and common Mechanical Instruments, he understands never so little the Use of the Tables of *Sines*, and the Computation of plain Rectangular Triangles, which may be learn'd by any reasonable Person, if he be rightly instructed, in a Week or less; in case he thinks this great and convincing Proof, of the Perfections of his Creator, deserves such Pains: However, if there be any who have no Inclination this way, they may pass by these Demonstrations, and proceed to the following Matters.

SECT. XVII. *Brief Demonstration of the Force of the Muscles.*

1. **N**OW to represent to an ordinary Capacity, and convey, in some measure, to the meanest Understanding a clear and distinct Notion of the great Force of a Muscle, as it were by Gradations: Let us suppose (*Tab. VI. Fig. 5.*) that the Muscle, *K D Q P*, is the *Deltoides*; of which mention has been made above (§. 14.) whose Office is to lift up the Elbow.

2. This, according to *Borelli*, (§. 82.) is a Radius Muscle, composed of several Plumiform Muscles, like *H Z Q L*, and *G V P W*. See below 154.

3. Let us here, for Plainness and Conveniency sake, imagine this Muscle to consist only of the
two

two plumiform Muscles, viz. H Z Q L, and G V P W.

4. How this Force will be calculated, when the Muscle is compos'd of more plumiform Muscles than two, will be made appear hereafter.

5. These Muscles are called Plumiform; because that in G V P W, the moveable Tendon, D G P has inserted into it, on both Sides, a great Number of carnous Fibres, as G V P W, all which like the single Feathers of a Quill, run parallel to each other, and are fasten'd to the opposite Tendon V P W, which being immoveable, cannot follow.

6. Seeing therefore, these carnous Fibres, G V and G W, are both of them fast and immoveable at V W; and seeing, that each of them is to be contracted by a Power, be it what it will; the Consequence must be, that of Necessity they are to be drawn upwards, together, from G to N.

7. After the same manner, likewise, the Point H is drawn up to O, in the other plumiform Muscle, H Z Q L, by the Contraction of all the lateral Fibres, as H Z and H L.

8. We see, that the Points H G, or rather the Tendons, D H and D G, being lifted up to O and N; the Point D, and therewith the Tendon K D, must necessarily follow directly, and be drawn up, in a right Line, to X.

9. If the Forces, which draw the Points H and G upwards to Q and P, be equal, the Obliquities or Angles, H D X and G D X, must certainly be equal also; then taking this for granted, as we suppose it is; it follows, that there will be an Equality in the muscular Fibres, aforementioned, not only as to their Obliquities or Angles, N G M, N G R and O H L; O H Z, which these, and all the other Fibres form with there moveable Tendons, H Q and G P; but there will also be an Equality to their Forces. M 2 10

10. These Angles HDX and GDX ; as also VGN and WGN , and in the other Muscle, ZHO and LHO (which form the Directions of the obliquely drawing Forces DG or DH , with the Direction of the perpendicularly drawing Force, DX ; and of the muscular Fibres, GV , GW , or HZ , HL with their moveable Tendons) shall hereafter, for Brevity sake, call *Angles of Obliquity*.

11. To proceed; let B be the Elbow upon which the Weight T , hangs; let BIA be the upper Bone of the Arm or *Humerus*; let $KEFA$ be the round Bone thereof, which can turn in the Cavity EF , in the Shoulder, about the Center C ; and lastly, let the Tendon DKI , which is inserted in the Bone at I , touch the round Bone at K , at the Extremity of it.

12. Thus it must appear to every one, that when the Tendon DKI (8) is drawn up to X , according to the Line KX , the whole Bone IBA , will turn about the Center C ; and K will be moved to n , and B to m ; 'tis plain the Weight T , by the contracting Power of the two plumiform Muscles, must thus be lifted up.

13. This therefore is a short Description of the Action of the Muscle *Deltoides*, when it lifts up the Weight T hanging upon the Elbow B ; or rather poising it in Equilibro.

14. To enquire further into the Force of this Muscle, let us begin from the Weight T , and proceed upwards to the Muscle.

15. This Weight T , according to the Observation of *Borelli*, (§. 84) is found to be 55 Pounds; which (the Weight of the Arm being included) is what being hung at the Elbow may tolerably be supported.

16. Since the Weight T draws the Bone of the Arm BIA downwards; and the Tendon IKD , draws the same upwards, by the Force of the Muscle DQP .

17. It

17. It is easy to perceive (and is what has been observed before) that these two Powers here do resist each other, like the *Steelyard*, or angular Balance, B C K.

18. We likewise see that the Arms of this Balance, B C and K C, are of very unequal Lengths.

19. Now every Body knows that a Weight, such as *t* here, drawing with a Chord *t r* D K, the shortest *Brachium* or Arm, C K, must be much greater than the Weight T, which hangs at the longest Arm, C B, to cause them to balance one another.

And therefore we see, by these unequal *Brachia*, BCK, that the Force of the Muscle D Q P, which draws the Arm K C, instead of the Weight *t*, must be greater than the Gravity of the Weight T, or 55 Pounds.

21. To proceed, then, to shew how much the Force of this Muscle must be greater than the Weight T: It is a known Rule in *Mechanics*, that if the Weights T and *t*, are fasten'd to a Balance of unequal Arms turning at C (which either hang straight down, as in *Tab. VI. Fig. 2*; or makes an Angle at C, as in *Tab. VI. Fig. 3*.) each of them drawing at right Angles at K and B, the respective Arms of the Balance, the Weight *t*, hanging at the shortest Arm K C, must be, in order to make an Equilibrium, so many times greater than the Weight T at the longest Arm; as the longest Arm, B C, is longer than the shortest Arm, K C.

22. Every one that doubts of this, may from Experience be convinced, by making such Balances or Steelyards, which may be affected, by bringing the Gravity of the Arm it self, in such a Position with the Weight, as Mathematically to observe an Equilibrium therein.

23. Now, granting the Rule (21) to be true, as it apparently proves to be; *Borelli* finds (§. 84.)

by exact Scrutiny, that the Length of the Elbow BC , (*Tab. VI. Fig. 1.*) from B , where the Weight T is suspended to C , the middle of the round Bone or Joint (which Length BC , makes the longest Arm of the Balance) is fourteen Times as long as KC , the half Thickness of the said round Bone $KEFA$; the Semidiameter of which makes the shortest Arm of the Balance.

24. For which Reason then, according to the foresaid Rule (21) the Tendon KD , drawing from the shortest Arm KC , ought to have fourteen Times the Force of the Weight T , in order to reduce the whole to an Equilibrium.

Now this Weight T , according to (15) the Observation of *Borelli*, is 55 Pounds: So then the Force, wherewith the Tendon KD must be drawn up by the Muscle, or by the Weight, in order to maintain the said Equilibrium, is equal to 14 Times 55, or to 770 Pounds.

25. And thus we see how much the Force, which the Muscle DQP exerts, must over-balance the Weight T , which it raises up only from the Head of the Steelyard BCK ; because it draws the shortest Arm KC .

26. For Instance, imagine the Tendon KD continued to r ; and further, suppose the Weight t , hanging perpendicularly from the Pulley at r , and so fasten'd to the Tendon KD , that the Pulley may play (or run round); 'tis manifest, that the Weight t must amount to 770 Pounds, if it poises the Weight T , or makes an Equilibrium with it.

27. But now if this Force of 770 Pounds were to be produced by two other Forces operating obliquely, according to DG and DH (instead of the Weight t , whose Power is directed by the straight Line KDr) we should perceive this Motion to be, according to what the two plumiform Muscles

Muscles, H Z Q L and G V P W, must necessarily be apprehended, by their moveable Tendons, D Q and D P, to produce.

28. It is then plain, that each of these two plumiform Muscles, H Z Q L and G V P W, must raise the half of 770 or 385 Pounds; it being granted, that the Forces, as well as the *Angles of Obliquity* H D X and G D X (10) of each plumiform Muscle, are equal to one another.

29. There does therefore occur in this muscular Structure another Machine, or rather a Pulley, whereby we may learn, that the plumiform Muscles will each of them exert a greater Force than 385 Pounds, or 770 Pounds together; and this Augmentation of their Force is owing to the Alteration of the Line of Direction of the Power which here draws, by these two Muscles obliquely; deviating, at the same Time, from the direct Line E D H *r*, and forming the Angles K D G and K D H.

30. To prove this, suppose (*Tab. VI. Fig. 4.*) a Weight K, of 770 Pounds, hanging at a Cord, K D *r*, which turning over a Pulley *r*, has as its other End, another equal Weight *t*, viz. of 770 Pounds capable of supporting the first Weight K.

31. Now let it be imagined, that this Weight *t* is taken quite away; but to supply its Place, two other Weights are substituted, viz. P and Q; the Chords of which Weights, viz. P *n* D and Q *b* D, run about the Pullies *n* and *b*; and both are fasten'd to the Rope X D at D; and from the Angles *n* D X and *b* D X.

32. It is plain, that if the Weights P and Q be equally heavy, and the *Angles of their Obliquity* (10) G D X and *b* D X, be equal, each of them must raise the half of the Weight K, which is computed to be 770 Pounds, that is to say, each must raise 385 Pounds.

33. This is what is observ'd before in the Case of the two plumiform Muscles, Z Q L, and V P W, (28) with no other Difference than here, instead of the two plumiform Muscles, two Weights, P and Q, are substituted, to render the Demonstration more intelligible.

34. But here occurs another notable and known Truth in Mechanics: If two equal Weights, P and Q, do hold in Equilibrium a third Weight K, with the Apparatus of Cords represented here, in *Tab. VI. Fig. 4.* and described (31) each of those two Weights, P and Q, must be so many Times heavier than the half of K (or 385 Pounds) as the Line D G is longer than D X.

35. Observing at the same Time, that the *Ratio* (or apparent Length with Respect to each other) of the Lines D G and D X, are found by taking *ad libitum*, a Point, as X, in the extended Line K D, and from thence drawing the prick'd Line X G, so as to make the right Angle G X D.

36. To know then how many Times the Weights P and Q are each of them greater than the half of K, or 385 Pounds, we need only enquire how many Times D G is longer than D X.

37. And this is found by knowing the Chord of the *Angle of Obliquity*, G D X (or the Number of Degrees subtended by a Line falling at right Angles at X; and cutting Part of the Arc of the Circle at the Points X or G, the Centre of which Circle is to be at D): Therefore, having found the Angel G D X, the Angle D G X is known of Course; because the whole Triangle being rectangular, the two Angels G D X and D G X, must be equal to one right Angle, or the Angle D G X.

38. After which (35) drawing a Line at Pleasure $d x$ (*Tab. VI. Fig. 5.*) and so as it may be divided into 385 Parts, by a Pair of Compasses, and drawing from it at x another Line $x m$, which makes
the

the right Angle $d \times m$, and drawing from d another Line, $d n$, which must cut $\times m$ at g , and form with $\times d$ the known Angle of Obliquity $\times d g$.

39. Then if we measure the Line $d g$ with the Compasses, and observe how many such Parts (of which 385 make up the Line $d \times$ in this Instance) are contained in the said Line $d g$, we shall find, in this Case, the Parts of $d g$ to amount to about 442,4. Whereby it will be known that $d \times$, in Fig. 5. or D X in Fig. 4. Is to $d g$, or D G :: As 385 : To 442.

And according to the Rule (34) that the Weight P or Q, will each of them amount to 442 Pounds, and consequently so far exceed the half of K, being 385 Pounds: By this way, even those who do not understand Mathematicks, may be made to apprehend these Demonstrations.

41. But they who have made the least Progress in that Science, and are but tolerably versed in the Calculations of plain Trigonometry, may, without this round-about Way of Admeasurement, or making the new right angled Triangle $d \times g$, (Tab. VI. Fig. 5. have Recourse to the Tables of Sines, Secants, and Tangents, with the same Ease as if the Line D X (Fig. 4.) were really divided into 10,000,000 of Parts; or, if so much Exactness be not required, into any less Number.

42. For if you search those Tables for the secant Line of such a Number of Degrees as the Oblique Angle G D X contains, you have exactly the constituent Number of Parts of the Line D G.

43. And comparing these 10 000,000 Parts, with the Number found in the Secant corresponding, you will have the Proportion of D X to D G; or know how many times D G exceeds D X in Number of Parts; and consequently how much heavier the Weight P is than the half of the Weight K.

There

Therefore it appears,

44. That as the *Radius*, or 10.000,000 : To the Secant of the *Angle of Obliquity* G D X :: So is D X : To D G ; or (36) the half of the Weight K, to the Weight P.

45. Now to bring this home to our Case, *Borelli* finds (§. 82.) that the Obliquities of the Tendons D G and H D (*Tab. VI. Fig. 1.*) upon the Tendon K D X, viz. the Angles X D G and X D H, are equal, each, to 30 Degrees ; and the Secant of 30 Degrees, as appears by the said Tables, is 11.547,005.

46. Now since an Inconveniency attends the Greatness of these Numbers ; and since the Calculation here before us does not seem to require so great Exactness, the Proportions may be sufficiently expressed, tho' as many Letters, or Cyphers be cut off from each of these Numbers (viz. 100.000,00 and 11.5470,05) as shall be thought convenient ; that if from each five Figures or Cypher be laid aside, the remaining Proportion, 100 and 115, will express this Matter clearly enough : Therefore, if D X were to be divided into 100 Parts, D G wou'd as much exceed D X as 115 exceeds 100.

47. Supposing the Case to stand thus : These 100 Parts (or the Radius) according to (34) : Are to 115, or the Secant of 30 Degrees (or D X to G D) :: As 385 Pounds, or the Half of the perpendicular Weight K : To 442 Pounds, or the oblique suspended Weight P (*Tab. VI. Fig. 4.*)

K

Which is in brief thus ; D X : G D :: — : P, or

2

the same in Numbers ; 100 : 115 :: 385 : 442.

48. Now this Weight P, represents the Force of the plumiformar Muscle, G V P W (*Tab. VI. Fig. 1.*) which therefore in this Case must be 442 Pounds.

49. And

49. And thus we see how the muscular Force, which was augmented before (24 and 25) by the shortness of the Arm of the Steelyard, is here yet more augmented by the Obliquity of this Draught tending towards DP; namely, from 385 to 442 Pounds.

50. So that in case the Tendon DP, were lengthened to s, and moved about a Pulley there, a Weight q, must be suspended to it there; and likewise one of the same bigness must draw the Tendon DQ, to the End, that by making together 884 Pounds, they may raise directly, or perpendicularly, the Tendon DK, by their oblique Draught; whose Force, according to the Direction D X, is equal only, to 770 Pounds.

51. But if, farther, we shou'd again remove the Weight q, as before, and raise the Tendon DG, according to the Direction DP, with the same Force of 442 Pounds, by the Help of the two obliquely acting Powers, according to G V and G W.

52. The same Machines or Pullies occur here as before (29, &c.) (*Tab. VI. Fig. 4.*) and the same Properties in all Points.

53. And it follows (32 and 33) that the Powers S V and G W, acting accordingly (*Tab. VI. Fig. 1.*) each will raise to the half of 442, or 221 Pounds.

54. As also, that the Force G W, in order to operate as aforesaid, must be as many times greater than 221 Pounds, or the half of the Weight q, as G W is longer than G S; supposing again (35) that G S W is a Right Angle.

55. The Proportions of both which, G S and G W, are found, if the *Angle of Obliquity* S G W be, moreover, known; after the same manner as we have shewn above (from Proposition 35 to 44.)

56. That is (by the Rule 44) As the Radius, or 1000,000 : ls to the Secant of the *Angle of Obliquity* S G W (or by 34) :: So is the Half of 242 or 221 Pounds;

Pounds : To the Force that must act according to G W.

57. Now, in order to discover the Power of this last Force, *Borelli* finds (§. 82,) that the *Angle of Obliquity*, S G W, made by the contracting of the carnous Fibres G W, with their moveable Tendon G P, is an Angle of 8 Degrees; the Secant of which (striking of the two last Cyphers) appears by the Tables to be 100,982 : 58.

58. And consequently according to 47.

As 100,000, or the Radius: To the Secant of 8 Degrees, or 100,982 :: So is the Force of 221 Pounds drawing directly: To 223 Pounds; or the Force which draws obliquely, according to G W, when it raises the said 221 Pounds perpendicularly, according to the Direction G S.

Which in short stands thus ;

$$100000 : 100982 :: 221 : 223.$$

59. So then the carnous Fibre G W, exerts a Force of 223 Pounds in this Case when it operates singly; and when the plumiformar Muscle, G V P W, has no more than this only moveable Fibre, G W, on this side.

60. We will suppose it to be really so, in order to render it more intelligible to unexperien'd Persons; and afterward briefly shew, how it wou'd be, in case there were in each half G P W, of the plumiformar Muscle, as many more Fibres as may be imagined.

61. In the mean while, since according to this Supposition there are two plumiformar Muscles, as G V P W and H Z Q L, of which this great Muscle, or *Deltoides*, is composed; and since each plumiformar Muscle has two Sides, each of which (59) exerts a separate Force of 223 Pounds, and jointly a Force of 446 Pounds; this then is the Force of the whole plumiformar Muscle, G V P W.

62.. That

62. Thus we see that this whole *Deltoides*, consisting of two plumiformar Muscles, or four half Sides thereof, by the Force of the Steelyard BCK (25) does balance, by the first oblique Draught of the muscular Fibres, GV, GW and HZ, HL, a Force, or Weight, four times 223 Pounds, or 892 Pounds.

So, that instead of the Force of each carnos Fibre, GW, &c. there hung, suspended, a Weight *p*, of 223 Pounds each; four such Weights must operate with the same Force, as the four Sides of the two plumiformar Muscles; and thereby the Weight T, hanging to the Elbow B, wou'd be kept in Equilibrium.

63. Now to pass on, further, to a greater Augmentation of the Force of the Muscles, produced by the the Structure of carnos Fibres, GV, GW, ZH, HL, &c. which are moveable; and also produced by the Texture of the Muscles themselves.

64. We find, after the nicest Scrutiny, that these muscular Fibres WG (*Tab. VI. Fig. 1.*) have of several little, hollow Interstices; which, whilst the Fibres are extended lengthwise, as ABCDE (*Tab. VI. Fig. 1.*) are included within right Lines; but when the Power which extended these Fibres ceases, these Interstices appear in circular Figures, as wg, &c. (or GMW, *Tab. VI. Fig. 1.*)

65. If now, by the Fibre WG, being immovable at G, a Weight T, suspended to it, must be raised 'tis plain, that in performing such an Action, by any Force (whatever it be) the Breadth or Thickness of the said Fibre must be imagined to be encreased; and the Length, at the same time, must necessarily be diminished.

So that the Parts ABCDE (*Fig. 1. Tab. VII.*) being dilated, or made wider, do assume the Figures *abcde*; by which the Length of the Fibres WG, becomes visibly shortned; viz. from WG to wg; and the Weight T, at the same time, is rais'd up to t.

66. This Tumefaction, or Swelling of the Fibres; which compose the Body of the Muscle, does palpably appear in several Parts of our Bodies; and in several particular Muscles, which contract themselves in the Exercise of their proper Functions.

Let any Man, with either Hand, take hold of his other Arm just below the Elbow, to convince himself, whether or no he does not feel the Muscles of the Arm swelling and contracting themselves, when he opens and shuts the Fingers of the Hand which he squeezes that way below the Elbow.

67. Now whether the Figure of these long Particles, or little Tubes A B C D E (*Tab. VII. Fig. 1.*) be round, as *a b c d e*; or whether they may be imagined Square, as *a b c d e*, the better to determine their Co-operation with other Fibres, we shall not pretend here to decide; it being a Matter foreign to our present Purpose.

68. Neither do we here enquire after what manner, or by what Causes the Interstices A B C, &c. become thicker, or how they assume the Form of *a b c*, &c.; concerning which, we leave every Man to enjoy his own Opinion, till the true and certain Manner thereof be clearly and incontestably demonstrated.

69. This is certain, that each carnos Fibre, as W G, consists of a multitude of little Instruments, as A B C D E, each of which do become thicker and shorter in Motion.

70. The Truth of the last appears experimentally from above (66); it remains therefore to shew these little Instrument, *a, b, c, d, e, f*, &c. (*Tab. VII. Fig. 2.*) in each Thread, *a p*, where a Contraction happens (and consequently the Breadth must be augmented) are very many in Number, and the Minuteness of each exceeding fine.

71. Let us suppose, in *Tab. VII. Fig. 3.* *a e* to be a Fibre with Interstices; which, in its utmost

utmost Extension, reaches to e , or is of the Length ae ; at the Tendon whereof a Weight q , being suspended, it is held in an Equilibrium; but as soon as ae is contracted to ad , the Weight q is raised to P .

72. Imagining this Fibre ae , to consist but of one Machine, viz. $abcd$, it wou'd be able to rise the Weight q up to P ; because the Line ae wou'd even by this means be contracted to ad .

73. But that this will not answer the Motion of muscular Fibres, which we are here accounting for, appears;

First, Because when the Machine ae is so long, the Thickness bc , would be incomparably greater than we now perceive in contracted Muscles.

74. For if a double Fibre ae , were two Inches long, which, by contraction or swelling, must be blown up into the circular Figure $abcd$, the said Circle would be 4 Inches, and its Diameter bc , above one Inch and a Quarter; as is plain to those who know that the Circumference of a Circle is to the Diameter, As 22 to 7, or thereabouts

75. We have chosen here to represent an extended Fibre rather by a long Line, and a contracted one by a Circle, than by a Tube and a Globe, to which there Resemblance bears greater Affinity; because we wou'd render the Matter as intelligible as may be to all Capacities.

76. *Secondly*, If the whole Fibre consisted of one Machine only, as $abcd$, and one shou'd cut it across at bc , the whole Fibre would at once be disabled from contracting, or exerting its drawing Power, so that it could never draw itself back to a ; but more especially, if the Contraction be performed by filling the Machine, or by the Expansion of any Matter included therein; but in a Muscle cut across, Experience proves a Motion or Contraction, even after its Fibres are cut asunder.

77. If now the Fibre consisted of two Machines; $akgm$ and $ghdi$, and which shou'd be divided from one another at bc through g , the first Machine must be contracted to a , and the second to d .

78. But if this should happen at km , the Part akm being cut through, would not be able to contract it self to a ; not to mention the too great Thickness of km (as was observ'd before concerning bc) for which would be equally contradictory to Experience as the former.

79. Hence we are taught, that (*Tab. VII. Fig. 2.*) when the Fibre is cut through at b or g , or k or l ; or whatever it be, each Part is drawn back to its Tendon to which it is fastened, that is, to a and p ; for Instance, if the Fibre be cut at g , the Machines between a and f and drawn to a ; and those between g and l to p ; and thus we see, that by this means the Cut made through any Muscle is visibly larger than then the Knife which made it.

80. From whence we may conclude, that on both sides of the Cut, whether at gb or else where; there must remain some Machines unwounded, which have in them a contracting Power, notwithstanding the Separation; and by this means the Fibre is drawn inward, or contracted, after it is cut through in any Part.

81. For if either side should be left destitute of these Machines, so that none were to be entire or uncut, the Consequence must be, that that side so deprived of these Machines, could not be in a Condition to contain the Matter which is the Cause of the Fibre's swelling; and consequently the Fibre could not be actuated by any Power which would draw it towards its Tendon.

82. But seeing it is scarce possible to cut a Fibre through so near a or p (*viz.* at m or n) but that the Parts, as we find Experience, do shrink on both sides, as well the short side as the long, to their respective Places.

83. It

83. It follows then, that how little a Part soever, such as *a* or *l*, be cut off from the Fibre on one side, seeing it shrinks back, it must necessarily contain some Machines, at least one entire one, in it self.

84. And consequently from hence we may plainly conclude, that the Machines, whereof the Fibres are composed, must always be, each of them in particular, smaller than the Part cut off; and therefore of a wonderful Smallness.

85. From whence, then it follows, that the Number, at the same time, of these Machines, if the Fibre be of any considerable Length, must be very great.

86. *Borelli* (from whom the Reader may receive sufficient Satisfaction, concerning the multitude and minuteness of these admirable Mechanisms, §. i 15.) maintains, that since every Fibre is smaller than a Woman's Hair; each Cavity *ABCDE* (*Tab. VII. Fig. 1*) which being contracted, forms a Machine *abcde*, must therefore be finer than the said Hair.

87. Now if these Machines be as broad as long, each Fibre will contain as many of them length-wise, as there can lie Hairs breadth-wise on the said Length of this Fibre.

88. But according to the Calculation of the said, *Borelli* (§. *ibid.*) fifty Fibres, placed breadth-wise by one another, do not amount to the space of one Inch.

89. Wherefore, according to this Computation fifty of these Machines must go to constitute a Portion of a Fibre of one Inch in Length.

90. But for Caution sake, and to keep within Compass, that Author does not calculate above twenty Machines for every Inch of Fibre.

91. Which Calculation we may safely allow him; because, if any one may think it more convenient to imagine these Machines not to be altogether as broad as long, here is room enough to humour any such Conjecture: For by this means, these Machines will have their Length exceeding their Breadth by

$\frac{1}{2}$, *i. e.* they will be more than three times as long as broad.

92 To return then to the Force of the Muscles; there appears here, in each Fibre, a new Instrument of the following Structure; *viz.*

First, We see, in *Tab. VII. Fig. 1.* a great Machine *W.G.* consisting of several smaller ones, as *ABCD E, &c.*

Secondly, That they are so formed, each little Machine, *A* or *B*, being contracted by a particular Force, into Circles or Squares, or other Figures, *i. e.* expanded, as at *A* or *B, &c.* of otherwise (in another Form) at *a* or *b, &c.* contributes its share towards raising the Weight *T.*

Thirdly, That being joyned, or linked, to one another at *a, b, c, &c.* they do likewise assist each other in raising the said Weight.

Fourthly, When this Machine, *wg*, consists of more or fewer little Machines, as *a, b, c, &c.* which operate here at the same time, the Weight *T* must accordingly be raised to a greater or lesser Height (as the Number of Machines are multiplied or diminished) and consequently the same Weight *T*, will be moved with greater or less Velocity: For Instance; if there be ten times as many little Machines, contracting themselves, the Weight *T* will be raised ten times higher; and at the same time, it will acquire ten times more Velocity.

93. All these Properties being so useful and necessary for a right Conception of the Motions of the Muscles; and being a necessary Consequence resulting from their Structure; we shall endeavour to demonstrate them by a Machine (adapted by Mechanists to other sort of Uses) which seems to have a pretty near Resemblance to the Nature and Office of the Muscles in general, and to give the best Light into this Matter.

94. Let us then suppose a Machine (*Tab. VII. Fig. 4.*)

Fig. 4.) in which a Weight *T*, hangs at a Cord, which being wound about the Pulleys 1 *a*, 2 *a*, &c. and 1 *b*, 2 *b*, &c. in the manner described by the said Figure, is terminated and fast'ned to the Nail *d*.

Then to each Pulley, 1 *b*, 2 *b*, 3 *b*, 4 *b*, let there be suspended an equal Weight *g h m n*; which four equal Weights, pressing altogether, downwards, the Weight *T* will be thereby raised up and kept in Equilibrio.

95. Now we may see in this Machine of Pulleys, all the same Phenomena which have been manifested in the muscular Fibres (92); namely, that the whole Structure consisting of many little Machines, each does, by a proper Force, bear a respective Part in raising the Weight *t*; which altogether united, accumulate their Powers so as to prove mutually assisting the one to the other.

96. For, if the Cord be carried only from *t*, through 1 *a*, 1 *b*, and terminating at *e*, be there fast'ned to a Nail; we have a Machine, which acting by the sole Power of *g*, raises *t*. And in case the Cord be continued from the Nail *e*, on to the Pulleys, 2 *a* and 2 *b*, and be fast'ned to another Nail at *f*; this will be a second Machine acting by the Power *h*; which, if it be joyned to the first, will help to raise the Weight *t*.

97. If these Machines and Weights be multiplied, by continuing the said Cord farther on thro' 3 *a* and 3 *b* to *i*, and from thence thro' 4 *a* and 4 *b* to *d*, and so on; and a distinct Weight suspended to each, as *m* and *n*.

We shall have a great Machine produced, from all these little ones; in which the three first Things expressed in *Prop.* 92. and repeated in *Prop.* 96. will occur.

98. We see likewise, that the fourth Thing described (*Prob.* 92.) which seems to be of the greatest Importaace in this muscular Demonstration,

does here meet with an exact Resemblance; viz. by how much the Number of little Machines is multiplied, by so much the more swiftly will the Weight t be raised up.

99. This is easy to be apprehended by Consideration, without the Circumstances of Demonstration; if g only acts on the first Machine, which is supposed to end at e (96) and the Centre of the Pulley, $1 b$, being first to r , is drawn down to $1 b$, so that it has twice $1 b r$ added to its Length, in a terminate space of Time; suppose in one Pulse or Second of a Minute, the Weight t will be raised to T , in the same space of Time the height of t T , which is equal to twice $1 b r$.

Because the Pulley $1 b$ being thus run down from r to $1 b$, the whole Cord, $1 a$, $1 b$, e , passes thro' the Pulley $1 a$; which Cord retains, as we see, on each of the two Sides, viz. on the Side $1 a 1 b$, and on the Side $1 b e$, the Length of $1 b r$; and consequently is twice the Length of $1 b r$.

Now in proportion to the Quantity of Cord, running thro' the Pulley $1 a$, the Weight t must be raised from t to T ; which must necessarily be twice the Length of $1 b r$.

100. If now we joyn the second Machine, the Cord of which ends at the Nail f , with its particular Weight h , it may be easily (96) inferred that when both the Powers g and h concur in their Operation, to draw down the two Pullies $1 b$ and $2 b$, from r and r , which are above (the Length of $1 b r$ or $2 b r$, which are equal) in such case, I say, it may be infer'd, that four times the Length of $1 b r$ passes thro' the Pulley $1 a$, exactly in the same space of Time; as may be seen by the four Cords, $ABC D$; and consequently, that the Weight t will be raised to T , the height of $1 b r$, multiplied by four, in the said space of Time.

101. If therefore these Machines and Powers,

$m, n,$

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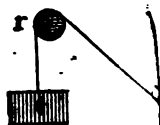


Fig.

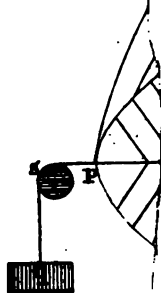
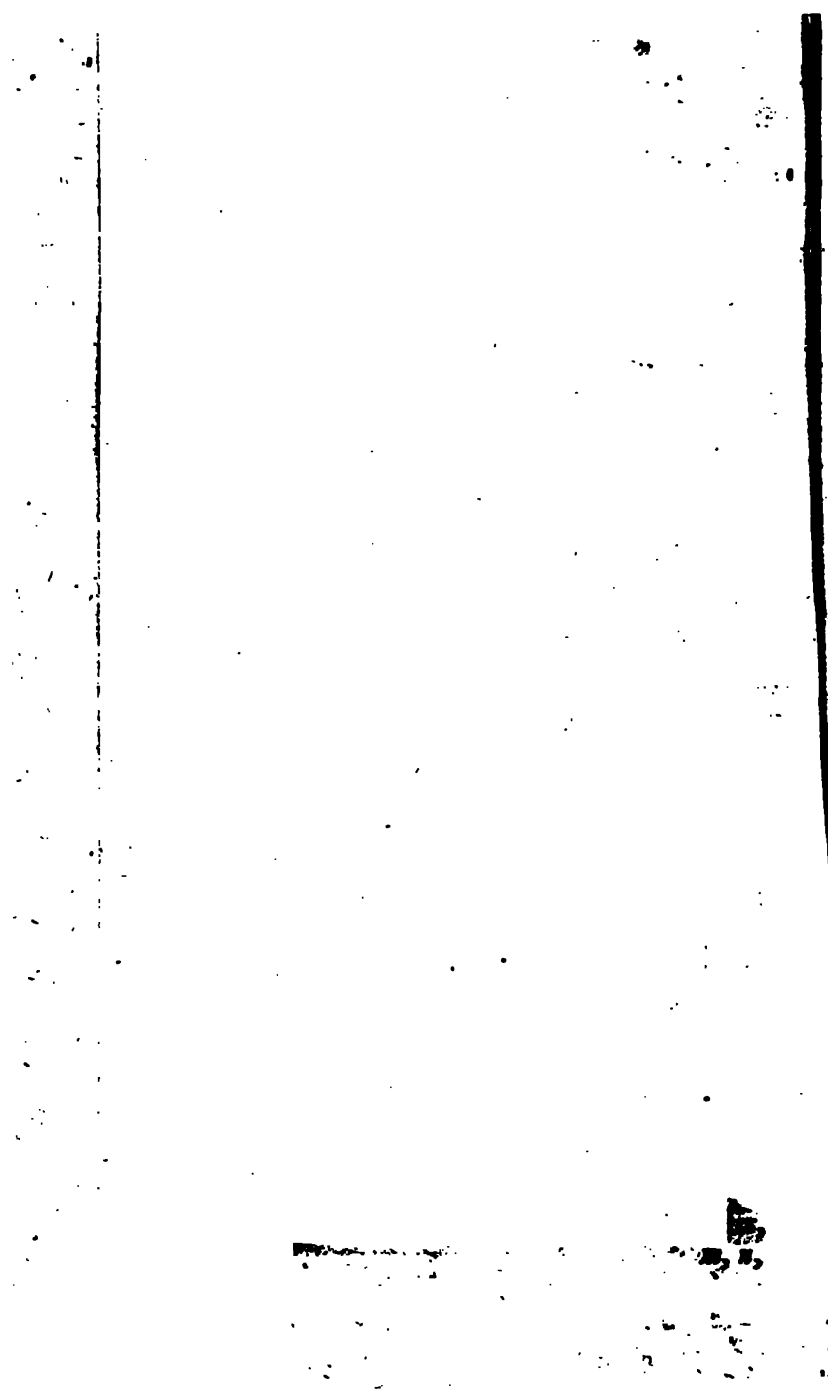


Fig.

cad

N 3

BB



m, n, &c. were to be further multiplied, and all the Weights drawn down together, in one Second of Time, it is plain that the Weight *t*, according to the Number of Machines, must always, in the same Space of Time. be raised higher; and consequently move with greater Velocity.

And thus what is said (92) concerning the Force of the muscular Fibres, is demonstrated in this Machine.

102. Now, since this Machine of Pullies operates after this Manner; those who are versed in *Mechanics* know that it is endow'd with the following Properties.

First, That altho' we take a greater Number of the several little Machines, and the Weight *g, h, m, n*, that draw them, yet they, joyned all of them together, will not be able to raise or poise in Equilibrio a greater Weight than *t* or *T*; which *g* only, operating by itself, cou'd poise the same way.

Secondly, But the Velocity, wherewith the Weight *t* rises to *T*, will, by the Multiplication of these Pullies, be proportionably augmented; *viz.* by how much the Number of these Pullies are increased, by so much swifter will the Weight *t* rise up to *T*.

103. To prove this, let us suppose the Pullies, *4 b, 3 b, 2 b, 1 b*, (*Tab. VII. Fig. 5.*) to be each of them brought inwards to *r, r, r, r*, by the gravitation of the Weights *T T* falling down to *t t*; so that the Pullies on each side, to wit, *1 a, 2 a, 3 a, 4 a*, may be in the common streight Line *d Q*, indiscriminately equal with the others, *1 b, 2 b, 3 b, 4 b*; the streight Line, *r, r, r, r*, passing directly thro' the Centre. *1 a*, from thence thro' *1 b*, at the Center, and so on; in this State the muscular Fibre *d Q* is to be apprehended to be extended to its full Length, and consequently inactive; and each little Space, *dd R. R, R R S S, S S B B*, and

BBQQ, will perfectly represent the little **Machines** of a Fibre which is in the State of Rest.

But if now the Side *dR* be extended both Ways, to *dDR*, the Space *dDRRDd* will in some measure, give us a Representation of one of the **Machines** of a muscular Fibre inflated, or swelled up, in performance of its Function; because the Cord by which the Weight **TT** is suspended, is raised so high by the said expansion or swelling, and shortned at the same Time so much below: By this Means we receive a gross Conception of the Action of the Fibres.

104. Since therefore the Properties enumerated (102) are very fitly applicated to this Machine of Pullies, as well as to every Fibre, which it is purposely adapted to represent; it occurs that the *sixth* Observation shou'd here meet with an Application.

105. Namely, that in order to compute the Force of a carnous Fibre, we must, according to what has been lately proved, multiply the Force of a single Machine of the same Fibre.

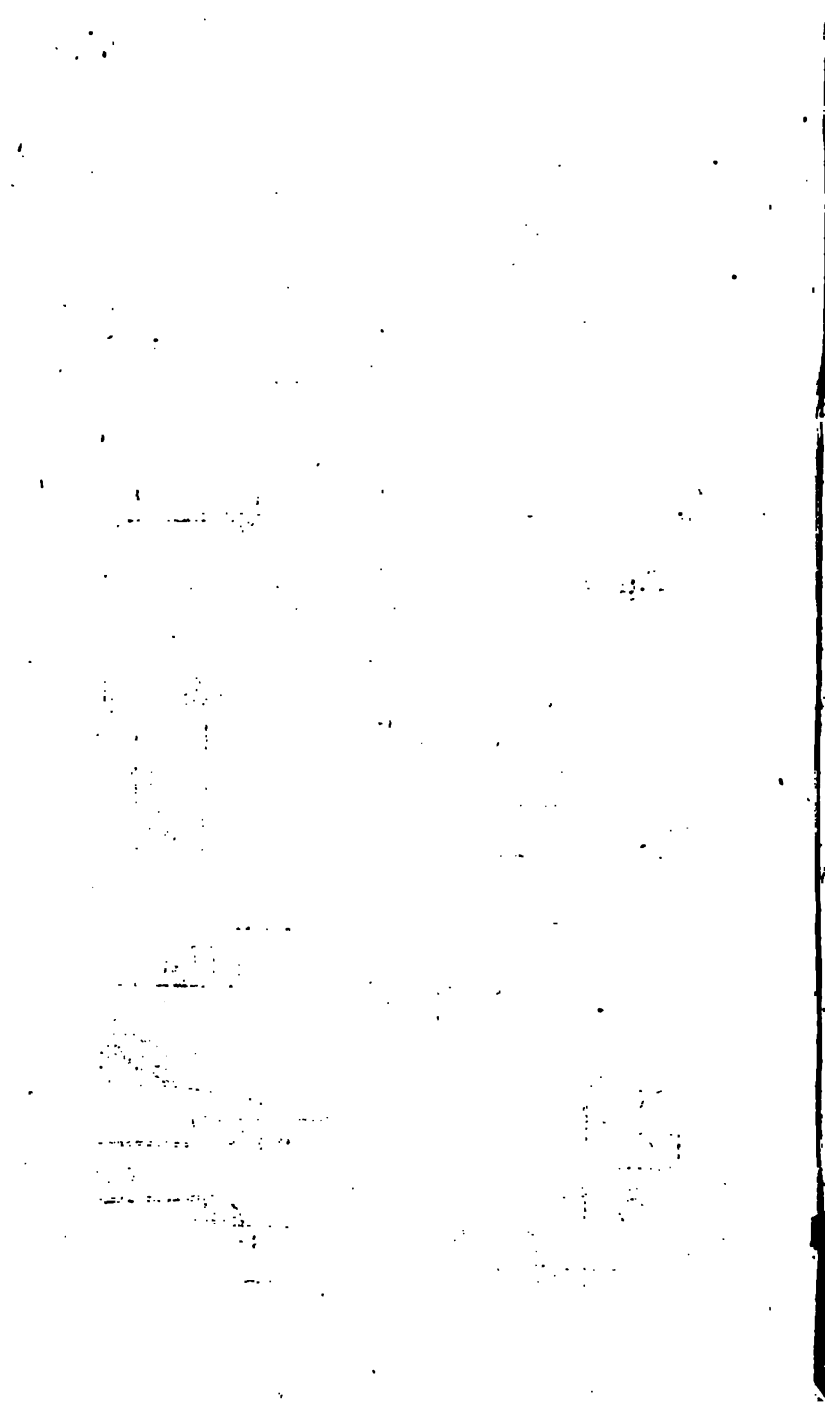
106. Now *Borelli* computes, (§. 124.) that each of the carnous Fibres of the *Deltoides*, viz. **GW** (*Tab. VI. Fig. 1.*) is two Inches in Length.

107. And, according to *Prop. 90.* each Inch contains the Number of 20 little Machines; five only (for Example sake) are marked here on the Fibre **GW**; consequently the whole muscular Fibre **GW**, being two Inches long, contains 40 of these little Circles, or rather little Globes.

108. Each of these little globular Machines, **GM** (59) can exert a Force of 223 Pounds, towards raising **T**, or a Weight of 55 Pounds, which hangs at the Elbow; because (by *Prop. 102.* and 104.) one sole Machine, **GM**, can act as much as 40 in making an *Equilibrium*.

109. So that by multiplying the Force of 223 Pounds

prima



Pounds (which one sole Machine G M exerts) by 40, or the Number of small Machines in a single Fibre of the *Deltoides*, we discover the Force of the whole Muscular Fibre G W ; i. e. 40 Times 223, or 8920 Pounds.

110. Now since this *Deltoides* is suppos'd to consist of two plumiform Muscles, each containing two distinct Sides, or Ranges, of Fibres, as GVP and GPW, in the Muscle GVPW, as also HQZ and HQL in the other plumiform Muscle HZQL, in all four Sides (each Side here being represented by a * single Fibre G W) we must multiply (109) this Sum 8920 by 4, in order to find the Force of the whole *Deltoides*, which will then produce a Force equal to 35680 Pounds.

111. Now tho' this proves such a Force in this Muscle, as perhaps might seem incredible to a Person not conceiving the Demonstration ; and tho' this Force itself be more than sufficient for our Purpose, yet we shall however subjoin the Demonstration by which *Borelli* makes appear a Necessity of even doubling this Force.

112. *Viz.* It is obvious to Persons skill'd in Mechanicks, that a Cord K T (the Weight K (*Tab. VI. Fig. 6.*) being suspended to one End of the Cord, the other End being at the same Time fasten'd to a Nail T, which renders it there immovable) sustains as great a Weight, or Force, by the Suspension of the Weight K alone, as if it bore double the Weight of K.

113. This is manifest ; because the Nail T contributes as much to the straining of the Cord K T, as if the said Cord K T, had another Weight, *m*, equal to K in Gravity, hanging at the other End, which is suppos'd to be carry'd round the Pulley *r* ; for this last Weight K may be perceiv'd

* *Vid.* Prop. 120. where one Machine keeps the Weight T in Equilibrium, and 100 Machines can do no more.

to be as well balanced, or kept in Equilibrio by the Nail T, as by the other Weight *m*, equal to itself.

114. They who desire to see this Matter demonstrated more at large, may consult the aforementioned *Borelli's* ingenious Treatise, *De motu Animalium*, in the 10th Chap. of the first Part; it will answer our present Purpose, if these Matters be made merely intelligible, for the Use of such as are not thoroughly versed in Mathematicks.

115. Now to apply this to the Muscles (*Tab. VI. Fig. 1.*) it is plain from what has been said, that the Muscles there described, do represent a Sort of a Machine of Pullies; one End of the Fibres G V, G W, Z H, H L being fasten'd to the Tendons, V P W and Z Q L, which adhere as immoveably to the Bones, as the Cords in the Machine of Pullies do to the Nails *dd*; whilst the other, and moveable Ends of these Fibres G V, G W, Z H, H L, do each of them exert a Force (62) equal to 223 Pounds; or the Power of each of these moveable Ends is equal to the Weight *q*, which is supposed to weigh 223 Pounds: But all these four Fibres operating together, will balance a Weight of 892 Pounds.

116. If, according to *Prop. 112.* this Force be doubled, the Force which this *Deltoides* exerts, by the Position of each of its Fibres, amounts to 446 Pounds; and the Forces of all four acting together, to 1784 Pounds, besides the Multiplication of this Number by 40, which we are going to speak of, and concerning which, Mention has been made already, *Prop. 63.*

117. And since we have hitherto supposed, that each Fibre, in these Demonstrations, is endowed with one or more Machines, like G M; and forasmuch as, according to *Prop. 102.* and 104, one such Machine, as G M, can balance as great a Weight as all the 40 Machines of the whole Fibre
G W;

that
each of 45 Degrees.

125. Con-



G W; it will appear, since the Force exerted by each Machine is equal, that in order to calculate, or make an Estimation of the entire Force of the whole *Deltoides* (or of the four muscular Fibres constituting it) we must multiply this Number 1784 by 40, or the Number of Machines in each Fibre, which amounting to the Sum of 71360 Pounds, is the Force which (according to *Prop.* 102, and 104.) the *Deltoides* is capable of exerting.

118. Here this (*Tab. VI. Fig. 1.*) may likewise serve, in some Measure, to demonstrate from the foregoing Principles, the Force of the Muscles called *Glutai*, when they exert their Power in raising Weights suspended to the Heels.

119. The *Glutans Major*, which is the Muscle we are to speak of, is, according to *Borelli*, (§. 83.) made up like the *Deltoides* of plumiform Parts.

120. Suppose then B to be the Heel; *d* the Knee; K E F A the round Bone in the upper Part of the Thigh; the Weight, to be raised by the Heel B, must, according to *Borelli* (§. 85.) be computed to weigh 65 Pounds.

121. We perceive here, that the Shin and Thigh-Bone together (which are represented by B C) comprehend, in Length 31 Semidiameters of K C, or the round Bone of the Thigh.

122. If therefore an Equilibrium be to be made betwixt the Tendon D K I and the Weight T; the said Tendon cannot be raised to X, by a Force less than 31 times 65, or 2015 Pounds.

123. And if this Force is to be extended by two other Tendons D H and D G; each of them will not only bear the half of 2015 Pounds; but because they draw in an oblique Direction, will so much exceed the Half, or $1007\frac{1}{2}$, as D G exceeds D X in Length.

124. But *Borelli* says, in relation to that (§. 83.) that the *Angles of Obliquity* X D G and X D H are each of 45 Degrees.

125. Con-

125. Consequently (by the Tables of *Sines*, and casting away the five last Cyphers) as the Radius, 100 : To the Secant 45 Degrees, 141 :: So $1007\frac{1}{2}$: To 1420 Pounds.

126. So that each of the Tendons, D G and D H, being drawn obliquely, must be acted on as if a Weight of 1420 Pounds, like D P or D Q, were suspended over the Pulley P ; otherwise their Force will not be equal to the Weight or Power which draws K D, according to the Direction K X.

127. And again ; at D G, there are two other oblique Fibres, G W and G V : These, to operate in like manner with the former, will each of them contribute a Force sufficient to raise the half of 1420, viz. 710 Pounds, gravitating perpendicularly in the Direction G P.

128. But because they draw obliquely the Force which draws according to G W, will so many times exceed 710 Pounds, as G W exceeds G S in Length.

129. According to (§. 83.) of *Borelli*, the Obliquity of this Angle is 8 Degrees.

130. Therefore by *Prop.* 58.

As the Radius 100000 : To the Secant of 8 Degrees, 100952 :: So 710 : To $716\frac{2}{5}$ Pounds.

131. Therefore each Fibre G W, representing here one entire Side, G P W, of this piumiformar Muscle, must in the Case before us raise a Weight of $716\frac{2}{5}$ Pounds.

132. But further, according to *Borelli's* Computation (§. 125.) each of these Fibres is of the Length of three Inches ; consequently each contains in its Compositions 60 Machines.

133. Therefore let $716\frac{2}{5}$ (the Force found according to *Prop.* 130.) be multiplied by 60.

134. The Product of $716\frac{2}{5}$ multiplied by 60, 43014 Pounds, equal to the Force which this one muscular

muscular Fibre G W (or even the whole Side of one plumiformar Muscle, to which this Fibre is supposed to be equal) exerts towards raising up a Weight.

135. Now it being taken for granted, that the Muscle D Q P, consists of two of these plumiformar Muscles G W P V, and H L Q Z, containing betwixt them, four Sides: Therefore these two Muscles exerting a joyn't Force, will (by Means of their four Sides, or four such Fibres as G W) exert a Force equal to four times 43014, or 172056 Pounds.

136. But seeing that this Muscle does adhere at one End to a Bone, as if it were a Nail T, (Tab. VI. Fig. 6.) by its immoveable Tendon; and is only moveable, so as to carry a Weight, like K, at its other End; this Force is therefore yet to be doubled; because the Muscle, by its being fast'ned at one End, suffers as great a Strain, as if had an equal Weight suspended over a Pulley, at the other End.

137. Wherefore doubling 172056 (the great Force of this Muscle) we find that 344112 Pounds does correspond to the Power that the *Musculus Glutæus Major* can exert in performing its Function.

138. And this is what we take to be sufficient to insinuate a general Idea of these Matters: If any one desires to see a more accurate and exact Account, he may meet with more ample Satisfaction in the said Book of Monsieur Borelli. We have been more brief in this Instance of the *Glutæus*, because we judged it a needless Trouble to repeat Verbatim what has been demonstrated more fully before in the Case of the *Deltoides*.

139. We might here conclude this Work, of demonstrating the Force of the Muscles, if some Objections did not intervene, which might hinder Persons

Persons not thoroughly skill'd in Mechanics (for whose Sake we condescend to this prolix Way of Demonstration) from acquiescing in the Proofs that have been deduced from mechanical and mathematical Observations: These Objection therefore we shall endeavour to obviate by suitable Remarks or Observations.

140. The first Difficulty that may perhaps be started, is that in *Tab. VI. Fig. 1.* we have represented one single muscular Fibre in the Room of an innumerable Number of others, which constitute the whole Side of the plumiformar Muscle *GWP*; Moreover, it seems agreeable to Observation, that one of these plumiformar Muscles, represented by *GVPW*, is not confined to two plain Sides, *GWP* and *GVP*; but diffuses its carnous Fibres, Pyramid-wise, in great Multitudes from a Point, as *G*, like a *Verticillum* or Wheel, in the Shape of the Extremity of the inverted Pyramid, *VGW*: This happening from all the Points, *GN*, &c. of the middle Tendon *GD*, these Fibres do in no fashion represent a Plane; but constitute the Figure of a perfect Body, with Length, Breadth and Thickness.

141. In answer to this; to shew that our supposing these Muscles to consist of plane Sides (which is a Method we have judg'd most expedient to convey these Demonstrations to the Understanding) does not in the least alter or enervate the Force of the Demonstrations; and to prove that the same prodigious Force wou'd manifest itself from every particular muscular Fibre, tho' the Calculation had been made from a greater Number of the Fibres of a verticillated Body, instead of the two Fibres *GW* and *GV*.

Let such as read this, consider, *First*, that as we have only taken two Fibres, *GW* and *GV*, for the two Sides of the Muscle, *viz.* *GPW* and *GPV*

G P V (whether solid or plane) so likewise we have only ascrib'd half of the Force of the whole Muscle, G V P W, to each of these two Fibres, as by (61) where the Force of one carnous Fibre, acting according to *Proposition* 59, was found to be equal to a Weight of 223 Pounds; to represent the Force of the whole Muscle G V P W, we were under an Obligation of doubling 223 Pounds; so that the full Force of a Muscle is represented by the Force of two Fibres, or 446 Pounds; this is the Foundation of what is to follow.

142. Now, for the Benefit of unexperienced Persons, we thus compute, that the Force of a Muscle is the same, whether this Force be imagined to be center'd in two Fibres, as G W or G P; or whether the Force be distributed amongst an infinite Number of Fibres, contained in the Space G V W P; which Space you may imagine, if you please, to be occupied by a Body consisting of Length, Breadth and Thickness, and not a mere plane Figure.

To this End, suppose (*Tab. VII. Fig. 6.*) a Weight D (not unlike *Tab. VI. Fig. 4.* and *Prop. 48.*) of 442 Pounds, suspended at a Cord D O S, and supported by another equal Weight *q*. Now if we take away this Weight *q*, and balance the Weight D by a Number of other Weights fastned to oblique Cords, G, A, P, &c. each of which bears a Weight *m, b, g, p, n*, &c. on this Account.

If we now conceive the Cords to be so order'd, that there may be imagined 100 Points, like G A P, &c. in the Length of the Cord G O, to which the oblique Cords, G W, G Q, A B, A E, &c. are fast'ned: And moreover, that there are about each Point, as G, or A, or P, &c. not only two Cords, as here at G and A, but imagine 10 to be placed round the Circle, like the Spokes of a Wheel, or *Verticilla* of a Plant; four such Cords
we

we have described to issue from the Point P, *viz*: P V, P T, P H, P R.

Lastly, let it be also supposed, that the Weights g, h, m, n, p , are equal to one another; and that the oblique Angles, M G N, B A P, R P O, &c. which each oblique Cord makes with G O, are also equal, and of 8 Degrees each.

It is therefore demanded, what the Weights g, h, m , &c. drawing obliquely, amount to? And how great a Force they mult altogether, in Conjunction, exert, in order to balance the aforementioned Weight D.

143. To find this, it must be considered, that we have imagined the Weight D to be drawn by a thousand Weights, equal in gravity to one another: Since (according to *Prop. 142.*) there are supposed to be 10 obliquely drawing Weights, and also we have imagined 100 such Points as P

144. Wherefore each little Weight g, h, m , &c. must raise one thousandth Part of the Weight D; or according to (142) a Gravity of $\frac{4\frac{1}{2}}{1000}$ Pounds; which each was able to sustain in the direct or perpendicular Line G O.

145. But considering that they draw obliquely; each such Weight as m , must exert a Power so many Times greater than $\frac{4\frac{1}{2}}{1000}$ of D, or than $\frac{4\frac{1}{2}}{1000}$, as the Line M G is longer than N G.

146. Now forasmuch as the oblique Angle N G M, of each is, according to *Borelli* (57) of 8 Degrees; therefore by (58) if G N be 100000, G M must be 100982: It follows (if they operate proportionably) as G N: To G M:: So $\frac{4\frac{1}{2}}{1000}$: To $\frac{4\frac{1}{2}}{100982}$.

147. So that each little Weight, as m , must have the Gravity of $\frac{4\frac{1}{2}}{100982}$, which is the first *Postulatum* (142.)

148. Now the Method, by which the Power of all these little Weights, when they exert themselves in

in order to raise D, or 442 Pounds, is to be discover'd, seems to be the plainest thing in the World: For do but multiply the Force which one of them, as *m* for instance, exerts, *viz.* $\frac{442}{1000}$, by the Number of all the little Weights, that is by 1000, and the Product is the Force of them all acting together, which appears to be 442 Pounds; the same which was demonstrated by the joynt Action of only two Fibres.

149. By these Weights and Pullies, you may imagine all the Power which is exerted by every single Fibre of a plumiformer Muscle, such as G V P W (*Tab. VI. Fig. 1.*) to meet with a just and analogous Representation.

150. For you may observe, that Weight of 442 Pounds is as exactly equivalent to the Power exerted by this whole Muscle G V P W, when you have supposed it made up of a thousand Fibres, as when before, according to (61) we imagined it to consist of only the two Fibres, G W and G V.

151. And from hence, by a little Attention, what we have said above, at *Prop. 141.* may appear exceeding plain and easie to any ordinary Capacity: Namely, that altho' the constituent Fibres of a Muscle were imagined to amount to ten, or a hundred, 'thousand, of the highest Number you can suppose, the very same Force, of 442 Pounds, will always, by these Methods of Calculation, be the result of the whole.

152. And to proceed yet further; we shall find the *Deltoides* exerting the very same Force; tho' we suppose (*Tab. VI. Fig. 1.*) to be an unjust Representation, on the account of the Number of the plumiformer Muscles; tho' we imagine the *Deltoides* not to be confined to two, as represented by G V P W and H Z Q L; but contrary-wise, to be endowed with many of these plumiformar Parts; yet we shall easily perceive, that the Force, or Power

Power of it being calculated according to the foregoing Rules, the Whole will be exactly congruous to the Power or Force already demonstrated.

153. And thus the Objection, which seemed to oppose this Hypothesis with the greatest Appearance of Reason, vanishes; and the Difficulties, under which might labour to conceive the possibility of two such Fibres, as G W and G V, being able to support together 446 Pounds, or each of them single half of that Number, are quite cleared and taken away: Especially when it is consider'd that we have only all alone laid these things down by way of Supposition, but by these *Data* however, the whole Force of the Muscle comes to be exactly accounted for: The Consequence proving the same, whether we suppose the Muscle constituted of a million of Fibres (as in all appearance there are a vast Number) or of only two.

Let the Figure or Structure of these Muscles be what it will, this Method may serve for a Sample to shew by what Methods their Power and Force are to be investigated.

154. In all these Reflections, viz. on the prodigious Number of Fibres; on the curious and peculiar Form of the Muscles, which represent Feathers joyned to a Tendon, as to a Quill (on which To-pick consult *Tab. V. Fig. 10.* where the Structure of the *Deltoides* is drawn from STENO's *Myologia*;) and, lastly, on the prodigious and almost incredible Force exerted by them; in reflecting, I say, on all these these, the adorable Wisdom of the great Creator, must most singularly manifest itself.

Steno represents the *Deltoides* consisting of 12 single Muscles; that is six plumiform Muscles on each side: And if you imagine the empty white Spaces, above and below, to be full of carnosous Fibres (as Steno affirms, *p. 53.*) how vast must the Number be conceiv'd to be? And as to the Force, which

which *Steno* demonstrates them to exert, according to his form, it cannot be much less than he asserts. But we have chosen rather to follow *Borelli* in our Representation, according to *Tab. VI. Fig. 1*; because by this Means we apprehend our Demonstrations better adapted to Capacities unexperienced in Mechanics.

155. But to penetrate further into the prodigious Number of the Fibres, and to discover, as far as possible, the wonderful Design of the Creator, we need only observe (to keep to the instance of *Tab. VI. Fig. 1*.) that the two Fibres, *G W* and *G V*, are found to Balance separately, a Weight of 223 Pounds (59) that is jointly 446 Pounds; as they represent together, the whole plumiformar Muscle *G V P W*.

If now, instead of two Fibres, we suppose (143, &c.) this Muscle to comprehend 1000 Fibres; each of these thousand Fibres will bear $\frac{446}{1000}$ of a Pound; that is not half a Pound to each Fibre.

And if the Number of Fibres were to be imagined greater, the Weight ascribed to each, to bear for its Portion, wou'd prove much less: Or if the *Deltoides*, according to *Tab. V. Fig. 10*. instead of two Muscles comprehend six (154); each Muscle could then have its share or burthen, but $\frac{1}{3}$ of 446 Pounds, which is not quite 150 Pounds each: Thus the 1000 carnosus Fibres constituting each Muscle, cou'd have to its Share no more than $\frac{446}{1000}$ or $\frac{1}{2}$ of a Pound.

156. Now who, apprehending this Structure of the Muscle, can think on it, without acknowledging the Wisdom of the Creator? Who has made the Tendons tough and strong enough to bear, without breaking, the Violence of the Force which they are obliged to suffer in exercising the Qualities they are endowed with: At the same time, having regard to the Safety of the most fine and tender Fibres,

by laying no more stress upon each of the Fibres in its Office than it is, by the Assistance of such a Multitude of its Fellows, able to sustain, without the least Injury.

157. For the Weight, which each Fibre sustains will be much less than $\frac{1}{2}$ of a Pound (155) if the Number of Fibres in each plumiformar Muscle much exceeds it (as 'tis probable they do) 1000; which was what we supposed (155) them to be.

It would therefore be worth any ones Trouble to investigate the Number of Fibres in each Muscle, as near as possible; not only to clear the determinate Number of Fibres composing each Muscle (which might be done by those who with accuracy pry into dissected humane Bodies) but also to adjust exactly how many of these Fibres, placed breadth-wise, may be contained within the Space of an Inch. *Borelli* says (§. 115.) that 50 Fibres thus placed, will scarce amount to an Inch: And as to the Number of Fibres in each Muscle we may judge, from the Flesh of Beasts, that many of these carnosus Fibres make but a small Portion of such muscular Flesh as we daily use in Food.

158. We shall cease to admire at what is advanced in *Tab. VI. Fig. 1.* concerning the Position that is here laid down, viz. that one sole little Machine, G M, of the Fibre G W (and so of the other Fibre G V) is able to support 446 Pounds, when we consider what follows:

The foregoing Propositions have made appear that the stress laid on each Machine, as G M, bearing not more than its Fibre G W, will not amount to $\frac{1}{2}$ or two Ounces and a half.

159. Thus the swiftness of the Motion imparted to the Weight T, by the contraction of the little Machines A B C, &c. (*Tab. VII. Fig. 1.*) where each of them are drawn up into the Form of *a, b, c,* &c. will not appear so improbable; seeing that if there

there were no Weight, such as T, suspended, the Conclusion (*viz.* that the Fibre to which T is suspended, must raise with the Velocity above-mentioned) wou'd be in itself the most obvious Thing in the World: Because, by the foregoing Proposition, the Weight is represented so small, that a single Fibre or Hair, can be put to no great stress to bear it; especially, considering that it has been already declared, that the Weight of 223 Pounds, ascribed (59) to a single Fibre (which is the chief Thing that can raise any Difficulty) is only thus supposed by way of *Hypothesis*; for the conveniency of conveying to the Mind such a just Idea of the Matter, as may do no wrong to the real Calculation

160. Now since we have shewed before (109) that tho' the muscular Force be ever so much augmented by the multiplication of these little Machines; yet, their disposition is proved to be such, that they all acting together, cou'd not raise the Weight suspended to the Elbow if it had been but one Pound heavier; and that the multiplying these Machines does only serve to encrease, or multiply, the Velocity of the Motion.

Therefore, Persons not thoroughly acquainted with Mechanics may yet, seem to question, how it can be possible that the Force of the Muscles is really augmented, when the Weight which is raised is in no wise encreased.

To answer this, they ought to be informed, that a really augmented Force is as much required to encrease the Velocity of Motion, as to raise a greater Weight with the same Velocity: This is what all Mathematicians know.

This also is made appear by the Pulley Structure (*Tab. VII. Fig. 4.*) where the augmentation of the Velocity with which the Weight T is raised, requires each time more Force and new Weights, as *m, n, &c.* See the 5th Remark, 102:

161. That this obtains in other mechanical Instruments, is what Mechanists are convinced of, and what may be easily observed: For suppose (*Tab. VI. Fig. 7.*) AB to be a Balance or a Steelyard, turning about D, and the Arms A D and AB to be equal; as also, the Weights A and B: 'Tis very plain, that the said Steelyard A B being turned into the Position MK, the Weight A will run down the Arc A M, and the Weight B down the Arc B K in the same space of Time; and that the Arcs being equal Parts of the said Circle, they must likewise move with equal Velocity.

Therefore if the Weight B were to be balanced, when its Gravity is increased thrice as much as it was, or when two equal Weights G and H are added to it, the Weight A must necessarily be assisted by two others of equal Gravity, or have its Force multiplied by three, as we see it has when the Weights E and F are added to it. Again, if we would make B move with a Velocity three times as swift as it had before, let the Point B be removed to C, so that D C may be thrice as long as D B: Wherefore, when the Machine turns, and A describes the Arc A M, the Weight C will describe the Arc C L, in the same space of Time, which being thrice as great as A M, therefore the Weight C runs thrice as great as A M, therefore the Weight C runs thrice as swiftly as A or B.

But to balance this Weight C, when it moves thrice as fast as B, it is plain that the Weight A must be multiplied by three, or receive the Addition of two other Weights, each equal to itself, such as E and F; otherwise it cannot raise up the Weight B, which, placed at C, is equal to B G H; which happens on the account of that Velocity, receives a threefold Augmentation.

Thus the Objection started in *Prop. 160* is removed.

162. Before I conclude, 'tis incumbent on me to beg that the experienced Mathematicians will excuse my Prolixity; not only in the Demonstrations themselves, but in consuming Time to answer such frivolous Objections as might be started by Persons unexperienced in these sorts of Studies; which renders the whole too long and tedious for expert Judgments.

But if they'll please to consider, that this Calculation is wholly devoted to the use of unexperienced Persons, and not calculated for the Taste of nice Mathematicians, who are too well informed in these Matters already, to want such mean Helps; I hope I may obtain their Pardon. The Persons for whom these Demonstrations are collected, are such as being unexperienced, have not habituated themselves to heap up together any considerable Number of *Lemmata*, or previous Proofs, before they come to the Matter itself, whose Judgments cannot be informed in Things of this Nature, without enlarging the Style, and describing Particulars more Verbofely; which is a Means, I have imagined, will convey my Designs more plainly to their Apprehensions.

They that desire to view this Matter, as it is more expressly and accurately handled and demonstrated, may have recourse to that well digested Work, *De motu Animalum*, written by the great and celebrated Mathematician, *Borelli*: whose Principals and Observations we have here made use of; endeavouring in the mean time, to render his Demonstrations intelligible, by the conciseft and easieft Methods we cou'd devise, to such as have but little Knowledge of Mathematical Studies.

The End of the Demonstration of the Force of the Muscles.

SECT. XVI. *Convictions from the foregoing Demonstrations.*

Now to apply all this to the Views in which we have writ the same.

1. How these Muscles are adapted to the discharging those Motions which they perform, with respect to their Tendons and the Joynts of the Bones.

2. That to the End that the fine and slender Fibres may not be separated nor torn asunder by the Violence of their Motions, the Muscles are composed of such an infinite Number of the same, that each single one of 'em hardly draws, or bears any sensible Part of a Weight.

3. That every Muscle is form'd of so many small Machines, the Use of which is only to perform their Offices with the greater Velocity and Nimbleness; as we may with Wonder observe in the Motions of the Fingers, the Tongue, and many other Cases.

4. That among such an incredible Number of Fibres, all of which are so small as not to equal the Bulk of a single Hair of a Woman, not one of 'em can be displaced without Confusion and Harm.

Now can any Man, who is rightly inform'd of the Texture and Operations of these Muscles, without being reproach'd by his own Conscience, pretend they are thus fram'd without Wisdom or Judgment? And the Man may justly be laugh'd at, or rather be lamented, as one depriv'd of the use of his Reason, that will readily allow, that none of the Tools of a Joyner or other Artificer acquire their Figure, and perform all their Uses by mere Chance, or from Causes wholly ignorant of what they are doing; and yet to support his own Atheistical Notions, don't scruple to say the same of this amazing Structure of the Muscles. O deplorable and obstinate Infidelity! which to avoid owning the Wisdom of a God, that has wrought such Wonders

ders in the Bodies of all Men, is oblig'd to have Recourse to such unjust, unreasonable, and odious Opinions. For, that what happens to the Muscles may be most justly deem'd wonderful, and indeed, almost incredible to those who don't understand the foregoing Demonstrations, is deducible from hence; namely, that the Fibres of the only Muscle call'd the *Deltoides* (as we have prov'd above in *Numb.* 110) are capable of exerting such an amazing Force, and really do exert such a Force in the Case there mentioned, as if all of 'em acting or gravitating together at the End of one Arm of an equally poised Balance, were equiponderate to the Scale suspended at the other Arm in which there was a Weight of 35680 Pounds; from which also if there were but the Weight of one Ounce, or less, taken away, it would be able to raise up such an amazing Load.

Besides, we learn from what has been advanced above (*Numb.* 111, to 117.) that these same carnos and muscular Fibres, as delicate and fine as they are, being joyn'd together, do acquire such a solid and strong Texture, that altho' the said heavy Weight of 35680 Pounds were suspended at each End of 'em, both together, that is to say, the whole Weight of 71360 Pounds could not separate 'em from each other.

Let an Atheist reflect upon this by himself, as also of the Uses which the Muscles are found to have in human Bodies, and then let he himself Judge whether he can calmly and coolly deny that his adorable Maker is both powerful and wise.

After all this, can any one without being astonish'd at the Wonders of the Creator, consider that all the fleshy Parts of his own, and of the Bodies of most other Animals (which far exceed all the other Matter of the Body) are only composed of moving Fibres? Each of which, as fine and tender

as they are, have their determinate Uses; and in the manifold Extensions, Directions and Dispositions whereof, we may, as it were, feel with the Hand, these multifarious Views, Ends and Purposes of a wise Creator?

SECT. XVII. *The Different Course of the muscular Fibres.*

IN order to have a just and true Notion of the various and different Courses of the Fibres, we shall represent to you a few Instances in *Tab. VIII. Fig. 1.* where in the Muscle called the *Deltoides A*, you may observe the Fibres fast'ned immoveable upon the Shoulder *C*, and to the Tube or Bone of the Arm turning to the Joynt of the Shoulder at *D*, letting the Arm hang downwards, as it is shewn here with all its Fibres extended in their utmost Length. But when these Threads between *C* and *D* are contracted with any Force, as you may see them in the other Shoulder at *B*; then the Arm must be lifted up, as at *B E*.

The pectoral Muscle *K*, being likewise here inserted in the Breast-Bone, with one End of its Fibres at *F* immoveably, and with the other End *D*, in the Tube or Bone of the Arm, moveably; it appears, that upon the Contraction of the said Fibres they would draw the Arm, bending it at the Shoulder Joynt forwards to the Breast.

If we view the Course of the Fibres in the Muscle called the *Latissimus dorsi A, A*, (*Tab. VIII. Fig. 2.*) on each side, it appears that they draw the Arm downwards and backwards; for which reason *Anatomists* give it the Name of *Ani-Scalpror*.

In the *Gasterocnemii BB*, which lie in the Calf of the Leg, and are fast'ned the one above, about the Knee at one End, as the other is below to the Heel-Bone by a strong Tendon *C*; it may be observed, that the Fibres run strait downwards; wherefore upon the contracting thereof, the Heel Bone must
be

be moved backward and upwards, and the Foot downwards. If one lifts up the Heel-Bone, and lays ones Hand upon the Calf of the Leg, one may feel the Muscles swell and contract themselves in that Place. These few Instances may suffice to give any one a general Notion of the Motions of the Muscles by the Description of the Course of the Fibres whereof they are composed.

SECT. XVIII. *Convictions from the foregoing Observations.*

THIS wonderful Structure of the Muscles seems to me of too great Importance not to place them before the Eyes of such as are unexperienced in Anatomy, by the two Figures of the Muscles, as they lye upon a Human Body, before and behind. (*Tab. VIII. Fig. 1, and 2.*) taken from Dr. Brown; and very necessary to give a Handle to all sceptical Philosophers to ask themselves whether such a Machine as our Bodies (which is compos'd of as many other various and wonderful Machines as there are Muscles in it, and all which are applicable to a particular necessary Use) can ever be imagin'd to have been framed by Chance, and without Design? And which is more, whether they are forced to own herein the most perfect Wisdom, which has dispos'd of so many thousands of thousands of Fibres, and allotted to every one of them its proper Place and Form according to the Purposes for which they were made; and that all this is done in the Fluid or Liquor of an Egg (from whence most, if not all Animals proceed) and there acquires its Figure and Nature? And further yet, does it not discover and make manifest the Skill of the Maker, that this does not happen with such Order and Symmetry in one Thing only (which it may, be an Atheist might assert, tho' without Reason, to be purely accidental) but in Millions of other Objects?

C O N-



CONTEMPLATION XI.

*Of the Bones.*SECT. I. *The Transition to the Bones.*

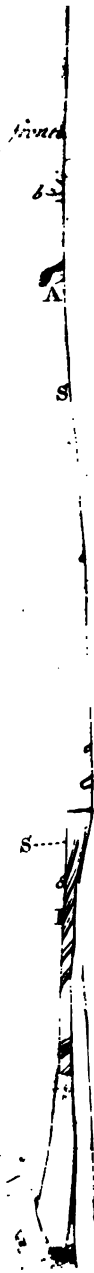
NOW whatever Art and Wisdom appears in what has been said concerning the Body; and with whatever Lustre the Things hereof may shine, how necessary and useful soever all its Veins, Nerves and other Parts may be; yet all this amazing Structure would be in vain, and the whole Body, like a wet Sack, would cling or stick together, and consequently hardly be in a Condition to exert any one Motion with Regularity, nor yet be able to remove one Foot out of the Place it was in; (wherefore it might perhaps have represented an ingenious and well-composed Machine, but yet at the same time would be really nothing more than a very useless, weak, and pitiful Lump,) unless the gracious Creator had at the same time vouchsafed to support it by the stiffness and hardness of Bones, and so render it proper to discharge its Functions.

SECT. II. *The Skull and Bones of the Head.*

THO' the Remarks that *Anatomists* have made upon Bones are numberless, we shall only here produce a few of the chiefest of 'em. And,

1. Can it be thought there was no Wisdom exerted, when we consider that the Brain being of so soft a Matter, might have been easily pressed and wounded by external Accidents to the Hazard of our Lives; to prevent the same, it is clothed and encompass'd with a hard Substance made of Bone, which we call the Skull?

2. That





2. That this Skull does not consist of one only hard Piece, but of several Parts joyned together, which may be divided by a kind of intervening Sutures, to the end that they may be moveable and yielding in unborn Children, at the time of their Mothers Delivery; for want of which, Mother and Child might both perish.

3. That such Moveableness ceases as the Children grow in Years, when it would otherwise be prejudicial, and then the principal Use of those Sutures, is to maintain a Communication between the Membranes that encompass the Brain and the Skull.

We see a great Proof thereof from hence; forasmuch as at the Top of the Head where the sagittal and coronal Sutures cross each other, there is found an opening between the Bones, which in new-born Children is all cover'd with a Membrane, upon which, if you lay your Finger, you may perceive the beating of the Parts in the Head; but in time the same is filled and closed by a solid Bone.

4. That the Skull, tho' every where of so solid a Substance, has yet Holes in it in all Places where it is necessary, to afford a Passage for the *Medulla Spinalis* and Blood Vessels from the Brain; particularly, that there are found in the Ears so many Angles and Cavities, artificially hewn out, as it were in Bones as hard as Rocks, for the Reception of the wonderful Instruments of *Hearing*, placed in such an Order as they appear to us.

5. That there is an Orifice in the upper Cheek-Bone, thro' which the Air passes by the Nose into the Lungs; and for want of which, no Child could easily suck, nor full-grown People themselves, keep any Liquor or moist Food long in their Mouths.

To say no more, it is obvious enough to every one, how great the Inconvenience would be, if a
Man

Man were forced to breath thro' the Mouth only, and not thro' the Nose.

Now those who would take the farther Trouble of considering the Bones of the Head in the minutest Circumstances thereof, and learn from Anatomy the Uses which the Diligence of Enquirers has hitherto discovered; might see, that among all the Number of them, that there is no Part, no Cavity, no Orifice, tho' never so small, but what has its necessary Use; and that not only for the Ease and Well-being, but even many times for the Support of our precious Lives.

SECT. III. *The Back Bone.*

BUT now as the Brain is encompass'd with a Bony Case, that it may not easily be affected by any external Inconvenience; the like Defence seem'd to be not less necessary to the *Medulla Spinalis* against all outward Harms; for that consisting of the soft Matter of the Brain, must be carried downwards in order to communicate the spiritous Juice thereof, by the Nerves to many Parts.

To this Purpose a hollow Tube of Bone, like that of the Leg, seems to have been sufficient, because it might have contain'd and secur'd the same against external Violence; but on the other hand, there occur'd an Inconvenience which must be prevented, namely, that the Body would remain as immoveable as if a Stake were run thro' it, and be entirely disabled from bending it self in any manner.

And again, if Joynts had been made in this Tube that includes the spinal Marrow, such as are in the Elbow, Fingers, &c. the following Inconveniencies would have happen'd.

First, That the Parts of this Tube making small Angles with each other, or being entirely bent down towards one another, the *Medulla Spinalis* must have followed such an Inflection, and the Course of the

the nervous Juice would have been obstructed by these acute Angles ; which of how great Consequence it is, is well known to those, who by the like Obstructions have not only fallen into Lameness, but even Agues, Putrefaction and Rottenness of the Bones, and have lost their Lives too thereby.

Secondly, Tho' none of these Inconveniencies should happen, yet the Body might by such sort of Joynts be bended forwards, and in some manner backwards too, but by no Means side-ways, as is plain in the Elbow and Fingers.

Indeed, if Articulations were to be made like those of the Shoulder or Hip ; and that the *Osculum*, or Knob of one Tube, should turn or be moved in the Cavity of the other, it is easy to see that the Inflection would happen on all Sides : But it is likewise true, that the spinal Marrow could not suffer more in any Disposition ; forasmuch as being obliged to run thro' the Thickness of such a Bone, it could not avoid being straiten'd and pressed by the Motion thereof, and soon render'd unfit for its Uses.

To prevent all these Inconveniencies, and to render the Body flexible on all Sides, and yet to avoid such Constriction of the *Medulla Spinalis*, by making some little Angles ; and chiefly to secure the same quite round, against all Occurrences, let the most skilful Engineer, or the greatest Mathematician, consider with himself, whether he could better solve this important Problem in Mechanics, and attain all these Ends by a more perfect Structure than that which the adorable Wisdom of the great Creator does here set before us. Those who desire a short Conception thereof, let them view *Tab. IX. Fig. 1.* where the Back-Bone is represented, consisting of a Number of little *Vertebrae* placed upon one another ; each of which has a great Hole in the Middle, in order to let the

the spinal Marrow pass thro' it, by which Means all of them together compose a hollow Tube from Top to Bottom; which being inflected, either right forwards or on either Side, do, by reason of the smallness of the said *Vertebra*, scarce make any Angles, or very little ones: In the same Manner as it were, as in the multangular Figure AEB, F, C, G, D, (*Tab. IX. Fig. 2.*) in which we see little and insensible Flexions, where if the Sides were made a little smaller; or, if instead of A E, two or more other Sides were taken, the Figure would be very near circular; that is to say, without any Angles at all, at least, any that are perceptible to us.

Now, since it appears from hence, that if we inscribe a Polygone in a Circle of fewer and greater Sides, as AB, BC, CD, the Angles ABC, BCD, &c. are much less and more acute than the Angles AEB, EBF, &c. which are made when the Circumference of the Polygone Figures consists of more and smaller Parts: We see likewise, that to prevent such acute Angles, it was here necessary, that the *Vertebra* should be very small, and therefore very numerous.

SECT. IV. *The Uses of this Structure of the Back-Bone.*

Now can any one imagine that the Division of this Tube into such small Parts as those of each *Vertebra* (which was just necessary in this Place and no where else) could have been made only here, and in no other Parts of the Body, without the wise and premeditated Purposes of a great Creator?

Moreover, because this Back-Bone was not to be moved by Joynts, but inflected without Angles, we see in the Figure above-mentioned, how this is most regularly brought about, by fastening each
Vertebra

Vertebrae to the next above and beneath it by an intervening Cartilage; from whence the three following and so necessary Uses do result:

1. That by the Intervention of such a Cartilage, the *Vertebrae* are hinder'd from rubbing and wearing out each other.

2. Forasmuch as in the bending the Back-Bone (on the right Side for Instance) the *Vertebrae* on the same Side must be brought nearer to each other; and upon the left and opposite Side at the same time must recede farther from each other: That this Cartilage has such a Faculty as to be able to serve for both Purposes, and to permit that the Back-Bone, by the mutual Approach of the *Vertebrae* at the Times of bowing or bending on the right Side, are pressed something closer together, and so render'd as it were thinner; and at the same time on the left Side proportionably extended, and so became as it were thicker.

3. And that which is particularly required here, is, that this Cartilage should likewise have an *Elaster* or expansive Faculty, which, upon its being compressed on the right Side, should cause it to rise up again; and when extended on the left Side, should likewise contract, or draw it in again.

Thus this Cartilage is not only proper to render the Inflection of the Back-Bone easy and convenient; but likewise to exert itself with a sensible Force for the Reduction of the same into its natural State after Inflection: The greatest Mathematicians having enquired into this with the utmost Diligence, have been obliged to acknowledge it for a wonderful piece of Work. *Borelli, Par. 58. De motu Animalium* calls it *Artificium Structurae Spinae Dorsi*, or the *Artificial Structure of the Back-Bone*, and begins his Enquiry by ascribing these and such like Matters, to the *Wisdom of the divine Architect*.

I know

I know very well that in the Dispute with Atheists, Authorities are of little Force towards their Conviction. Yet when we hear great Men, who have not this View directly in writing their Books, speaking after the same Manner, it is very probable that this can be ascribed to nothing else but the irresistible Convictions of their Conscience; wherefore it should seem that an unhappy Atheist, if Reason or Justice may have any Ascendency over him, might be so far influenced thereby as to enquire diligently and seriously into that which has made such an Impression upon great Minds; and then consider with himself whether it be not rather the want of Examination and of Judgment than strong Arguments that has given him Occasion to differ so much from the Sentiments of the most learned Mathematicians.

And this is the End we propose to our selves in writing these *Contemplations*; in Hopes that it may please the great and wise Architect of all Things, to have Compassion on them, and not to leave them under this terrible Curse of obstinately rejecting the Examination of what the Confession of a divine Being will demonstrate to them, and of remaining under a judicial Blindness, when nothing is wanting on their own Part but to *open their Eyes*.

SECT. V. *The Whirl-Bones.*

WE shall pass by the Wonders that might be observed in the Eminences or Heads of the *Vertebrae*, into which the Muscles are inserted for Motion; and in the Holes that are therein for a Passage for the Blood-Vessels; as likewise the Cavities that are between every two *Vertebrae*, and thro' which the Nerves that are derived from the *Mdulla Spinalis*, pass to their respective Parts; the least of all which may furnish us with sufficient Matter of Astonishment at the wise Designs of the Creator.

Par-

Particularly the Structure of the two highest *Vertebrae* of the Neck is very wonderful, which, because the case does here require it, and to the end that the Motion of the Head may not be obstructed, are each of 'em of a different Figure; and the second of 'em has an Eminence which serves for a Pin, upon which the Head may turn by the means of the first *Vertebrae*. He that desires to be farther instructed herein, may consult the Books of *Anatomy* which are in every one's Hand; and, if he be in earnest in his Enquiry into the Glory and Greatness of his Creator, make the right use thereof.

SECT. VI. *The Ribs.*

Nor to dwell too long upon the use of the Ribs, which form the Space and Cavity of the Breast, in order to leave room enough for the Heart and Lungs to move in, and at the same time to defend the latter from all External Violence: Let any one ask himself, whether it be owing to mere *Chance*, that these Ribs, in the part where they are fasten'd to the Cartilaginous Breast-Bone, are likewise compos'd of a Cartilaginous Substance, to the end, that when they move at Respiration or drawing-in of the Breath, they may be more easily inflect'd by the Muscles; and, after that the Operation of the Muscle ceases, they may, by their own Elastick Force, return to their former State, and thereby contribute very much towards Breathing.

Concerning their Power and Action, you may see what the Learned *Borelli* has said in his Second Part.

S E C T. VII. *The Hip-Bones.*

To mention cursorily the rest of the Bones, and particularly the Hip-Bones, with whose most necessary Service we should be sufficiently paid, if they were of no other use only, than to secure and strengthen the Wombs of Women, from whence all Mankind receive their Birth ; besides, that they afford both to Men and Women an immoveable *Fulcrum*, or Support, to the Thighs, Legs and Feet in bearing the whole Body : It should seem therefore that nothing remains, but to give some account of the Structure of the Arms and Legs, of which, as also of their Articulations and Joints, something has been already said in our *Contemplation of the Muscles*, since it was impossible to treat of these last with any manner of Clearness, without some knowledge of the former, to which therefore, if any one thinks it necessary, he may have recourse.

S E C T. VIII. *The Thigh-Bone.*

LET then a Philosopher that is enquiring after Truth, take into his Hands such a Thigh-Bone as we have described (*Tab. IX. Fig. 3.*) *AE*, and such as he may have met with many times in Church-Yards and Charnel-Houses, without taking any notice thereof, and he may see in this alone, the great Creator's wonderful Direction to so many necessary Uses. For he will find, *first*, that the same is very hard and stiff to enable it to bear the Body ; but at the same time hollow, that it may not incumber the Motion thereof by it's Weight ; and at the same time to be provided with a Marrow, that is so necessary, and to keep it ready for the Service which it is to perform, of which hereafter.

Secondly,

Secondly, That (in *Tab. IX. Fig. 4.*) the Knob or Head of the Bone *A* is round, and is so accurately adapted to the Os *Isciii*, or Hip-Bone *B*, that it can turn round therein, and be moved on all sides.

Thirdly, To give some slight Description of this Joint, since the Figure will help us therein; can we discover no Wisdom in the following Particulars? *viz.* *First*, this Knob *A* is surrounded with a kind of a smooth polished Cartilage, to the end that it may perform it's Motion without Resistance and without Pain. *Secondly*, that to give the greater Steadiness to the Joint, this round Bone *A*, is fasten'd in the Cavity as it were with a Rope or Tendon, by a Strong band *b*, which however does not obstruct it's Motion. And *Lastly*, that a broad Band, *a*, surrounding the whole Joint (but which in this Figure is represented as cut thorough) ties the whole together, still preserving the Freedom of Motion.

Fourthly, To proceed in the Contemplation of the aforelaid Thigh-Bone (*Tab. IX. Fig. 3.*) it has two Eminences or Heads, *DD*, at the place where it makes a Joint with the Leg or Shin-Bone below at the Knee; which are both likewise encompassed with Cartilages, that they may slip the more conveniently and smoothly. These two Heads, *DD*, or *bb*, (in *Tab. IX. Fig. 5.*) have between them a pretty deep Hollow or Groove *e*, and are both adapted to two Cavities *cc*, which are above in the Shin-Bone *K*; and that again has an Eminence lying between the two Holes *cc*, which is likewise adapted, and enters into the internal Angle *e*, between the Heads of the Thigh-Bone *bb*. Now, need we say any more to prove very evidently the Designs of the Divine Architect? And he who in any wise comprehends it, must he not be convinced that this Joint is of a different Structure than that of the Thigh-Bone; and that it ought to be so,

forasmuch as the Knee is only to be bent forwards and backwards, but by no means sidewise, as the Thigh-Bone, and that otherwise it would produce a very irregular Gate?

Fifthly, To say nothing of the Ligaments or Bands, which (as in the Joint of the Thigh with the Hip-bone) preserve all this from disjoining: Nor likewise of the Knee-pan, the use of which is best known to them who, having broken the same by any Mischance, are thereby deprived of the chiefest Strength of this Joint.

Could any one see that the little round Bodies *B* and *C* (*Tab. IX. Fig. 3.*) are of so great use for the Insertion of the Tendons of the Principal Muscles, and still suppose that this Bone had acquired it's Form without Design: In which, not one Eminence, not one internal Angle is to be found, which, if it had been of a different Structure, might not have occasion'd remarkable Inconveniencies to Men?

If any Body would see the manner of such a Structure at his Ease, he need only consider the Claw and Leg of a *Pullet*, and that to which it is fasten'd at both Ends, where he will find something very analogous to what we have now described. And let him, who reflects upon all these Things with care and attention, judge whether it be not as reasonable to acknowledge the wisdom of the Artificer in this case, as he would do in any other Machine made of Brass or other Metals? Which, tho' it would not be near so serviceable to living Creatures, yet would meet with less contradiction from this sort of Philosophers.

That the latter is true, is well known to such as converse with them; but however, it can't be deny'd that it is very strange and unaccountable, that they should own a greater Wisdom in a meaner, and less Artful Machine, and yet deny it in a better.

*

S E C T.

SECT. IX. *The Teeth.*

TO the above mentioned account of Bones, we might have added the particular Properties of those whereof the *Teeth* are compounded, and how they differ from other Bones, to the end they may be the better adapted to their own Uses. Now in case they had been produced by Chance, or by Causes operating without Understanding, why are these Bones exactly endow'd with the different Qualities which they themselves required? And why do they so seldom appear in the Mouths of Young Children in the first Months, when they would be both inconvenient to the Sucking Child and Painful to the Mother? And why are they produced at the time when the Stomachs of those Young Creatures are capable of digesting more solid Food?

Those who desire to be informed of other Circumstances about the Teeth, may consult what has been said above touching the *Mouth*, *Chewing*, &c.

SECT. X. *The Bones in unborn Children.*

THE Diligence of Anatomists has discover'd many Things in the Bones of Children before their Birth; and plainly shewn in several Cases the difference there is between those of one new Born, and of a Person in Years; yet it is still unknown of what Matter they are compos'd at the Beginning, and afterwards in their Changes, till they have acquired their Solidity and true Nature; and particularly, what were the real Causes of the whole.

So that no Body, who believes the Divine Origin of the Holy Scriptures, will be surpris'd, that

the adorable Spirit of G O D, with which the Writers thereof were endowed, has been pleased to make use of this Instance, to prove the Smallness and Narrowness of our Knowledge in these Matters, by the following Expressions, *Eccles. xi. 5. As thou knowest not what is the way of the Spirit, nor how the Bones do grow in the Womb of her that is with Child; even so thou knowest not the Works of G O D who maketh all.*

The Enquiries of the accurate *Malpighi*, where he treats of the wonderful Formation of the Bones of a Chicken in the Egg, are worthy to be consulted upon this Occasion; but without going so far, the few Observations that we have yet been able to make in the Bodies of Men, do confirm experimentally, and plainly enough, these Words of *Solomon*; when we see the Great *Harvey*, who is so justly esteemed throughout the World, on account of his famous Discoveries, thus speaking in his *Treatise de Ord. Part. in Generat. In the first Months* some of the Bones are soft, others cartilaginous; the Arms so short, that when laid upon the Breast the Fingers cannot touch each other; nor can the Legs, tho' folded upon the Belly, scarce reach to the Navel: And this comes from hence, that the whole Fruit has hardly the length of the Nail of one's Finger, till it comes to be as big as a Frog or a Mouse.

At first, there are formed little Fibres, or Threads, of the consistency of Slime, which are afterwards nervous, then cartilaginous, and finally of the hardness of a Bone. In the second Month (according to the several Experiments of the above-mention'd Author) the Embrio is very big in its Head, and very short in its Legs; and the whole Matter so soft and inconsistent, that it can hardly bear touching with the Hands; and in order to be examined, must be laid in Water; nor is there any Solidity in the Bones.

Now

Now will the most self-conceited Philosopher dare to maintain that he ever rightly knew, how the Bones of an Embryo are fram'd in the Womb? And if he is reasonable, must he not be convinced that this Hypothesis is wisely chosen to shew the smallness of Human understanding? And to the end, that it might convince not only the Philosophers of that Age, but likewise all that came after them, where their Knowledge is bounded and defective, and that it should continue so in spite of all their greedy and restless Scrutinies: Must he not own that the State of Things, and the Limits of Human Sciences, even to the latest Generations, were not less known to the great Inspirer of this Holy Word; and consequently that he who spake it, must be more than a Man; yea, that he could be no other but God, to whom only all future Events are clear and manifest?

SECT. XI. *The Bones are produced from a fluid Matter.*

BEFORE we proceed farther, let the Reader consider with himself, whether it can be thought, that an Over-ruling Power and Providence had no share in this Matter, when he sees hard Bones so wonderfully adapted to many Uses, arising only from a Slimy Matter, which owed it's beginning to nothing but Bread and Water?

For that the Bones, be they never so hard, do in a great manner arise out of a Fluid, is abundantly proved by the Chymists, who, having distilled the same quite dry, and without the addition of any Liquid Matter, do produce from thence a great Quantity of Oyl, and yet more of Watry Parts (in which their Volatile Salt is melted, and which therefore is called their *Spirit*) as is well known to such as have made the Experiment.

S E C T. XII. *Psalm CIX. ver. 18.*

NOW with how precise a Knowledge the Holy Ghost has spoken in other Places of Scripture, even of this internal Structure of the Bones, will appear as plain as the Sun at Noon, to such as from Chirurgical Experiments have learnt, that there is nothing more pernicious to a naked Bone, than to put Oyl or any other Moisture upon it, which will cause a miserable Corruption therein: On which account it is, that the most skilful Surgeons, in treating about the Diseases of the Bones, do most carefully warn their Readers against the same.

For an Instance hereof, one need only read the Words of *Hildanus*; *Ab omnibus autem humidis & oleaginosi in denudatis ossibus in quacunque corporis parte, plane ut abstineat Chirurgus necesse est.* P. 816. That is to say, a Surgeon must carefully abstain from the use of all Moist and Oily Matters in the managing of naked Bones, in whatever part of the Body they lie. As also Mr. *Paré* says, upon the same occasion, p. 560. *Moreover the Bones may be likewise Corrupted by the improper Application of any Oyls, or other Liquid Medicines.*

I have only produced the Evidence of these two Gentlemen here, because they may be justly ranked among the most Famous and Skilful Men in this Art.

For to return to the Matter again; Can any one that reads that Text, in *Pf. cix. ver. 18.* *As he clothed himself with Cursing, like as with his Garment: so let it come into his Bowels as Water, and like Oyl into his Bones;* and who has ever seen this *Caries Ossium*, or Corruption of the Bones, in any other considerable degree in a living Person, and has been informed that the same may be produced, or at least augmented, by any Liquid or Oleaginous Matters, must needs confess, that the Wrath and Curse of

GOD cannot be described by more lively Comparisons, since Water and Oyl, that are mentioned in this Text, are both of 'em the most pernicious Things imaginable to the Bones.

SECT. XIII. *Bones without Nerves.*

ACCORDING to the very Learned Anatomist, Mr. *Verbeyen*, the Bones having no Feeling, are consequently without Nerves, which are accounted by all as the Instruments of Sensation; but whether that be produced by their *Marrow*, *Juice*, or *Membranes*, we shall not here contend: The same is not obscurely maintained by a famous *English* Anatomist, Dr. *Clopton Havers*, who, tho' he differs a little from the former, touching the feeling of the Bones; yet, in his *Osteologia Nova*, or *New Description of Bones*, p. 29. he affirms, that having enquired as nicely as possible into this Matter, he could discover no Nerves in the Bones, but endeavours to shew how this want of the Nerves may be supplied; so again, speaking of the Nerves of the Teeth, p. 102. he says, that *there be other Bones to which it should seem that no Nerves do belong.*

SECT. XIV. *Marrow.*

BEFORE we conclude these Remarks concerning the Bones, we must say a word or two about the Marrow: Now can any one suppose that the Bones were made hollow without Design, since they serve for the Receptracles of a Fat or Oleaginous Matter, which renders the Limbs smooth, and supple in their Motions, and prevents the Cartilages in the Joints, when sliding upon each other, from being worn out or burnt by a continual Attrition, which wou'd happen if they shou'd remain dry, as appears by the Axel trees of Wag-
gons

gons and Mills, which are greased for that very purpose?

Not to mention here, that by the said Marrow, the Bones themselves (which being otherwise too dry, would become brittle) and the Ligaments or little Bands thereof are kept in their proper Condition by such a Moisture; as we see the Musicians oyl the Strings of their Instruments, to the end that they may not break by too much Dryness.

How plainly then does the Wisdom of the Great Creator shine forth in this very Matter, by contriving, in so hard a Substance as Bones are, Ducts and Passages thro' which the Marrow may ooze out or *filtrate* from the little Tubes of the Bones into the Joints?

SECT. XV. *Water and Oyl together serve to render the Parts smooth.*

THEY that deal with Air-Pumps (the Construction of which, to render the matter more intelligible to unexperienced Persons, must be supposed to be like a great Syringe) know, that the Sucker thereof must be first steep'd in Water, to make it swell out to the necessary Thickness and Softness; after which it is oyled a little, that it may move backwards and forwards more smoothly and readily; from hence it is plain, that when the Sucker, tumified with Water, is thrust with some Force into the Tube of the Air-Pump, which is narrower than the extended Sucker, the Water is pressed out and mingles itself with the Oyl that was smeared over the Sucker.

Now could any Body, who has never made a trial thereof (to add something here which is very remarkable) imagine, that Water and Oyl thus mixed together, are much more proper than Oyl alone, to cause two Bodies, rubbing against each other,

to move more smoothly and nimbly upon one another? And yet, that this is true, the aforeſaid Experiment has taught us; wherefore, it is likewise very uſeful, that the Sucker, already ſmeared with Oyl, ſhould be even once again dipt in Water, before it be thruſt into the Tube of the Air-Pump.

The firſt Obſerver hereof, was the great Mr. *Robert Boyle*, who, upon the account of his Enquiries into the Creatures, can never be ſufficiently praiſed; that Gentleman, in the Introduction to his *Phyſico-Mechanical Experiments*, p. 7. of the *Cologne Edit.* ſpeaks thus of this mixture of Water and Oyl, to render the Motion of his Air-Pump more eaſie: *Upon which occaſion we muſt not here omit (becauſe it appears ſo wonderful) that neither Oyl nor Water uſed ſingly, could bring to paſs that the Sucker ſhould be moved eaſily and readily; but that a mixture of them both (ſeveral times repeated to our great ſurpriſe) did produce the deſired effect.*

Thus we ſee that a Gentleman, who, if he can't be called the greateſt Philoſopher in the World, yet may juſtly be placed in the firſt Claſs of Great Men, acknowledges himſelf, that he could never have diſcovered this by Argumentation, but learnt it (*to his great ſurpriſe*, which ought to be well obſerved here) by Experience only.

SECT. XVI. *Oyl and Water thus mingled, inſinuate themſelves into the Joints.*

Now let the Atheiſt, that has never ſo high an Opinion of his own Underſtanding, or the ſtrong-eſt Mind (as they love to call themſelves) ſeriouſly conſider by himſelf, laying aſide all Obſtinacy and Paſſion, whether he can aſcribe all this, with the leaſt appearance of Reaſon, to *meer Chance*, or *ignorant Cauſes*; when he ſees with his own Eyes, that, in order to render the Joints more ſupple and moveable,

able, and to produce such a mixture of Oyl and Water as would be fit for that purpose, there are found, in and near the said Joints, perpetual Springs and Fountains; out of some of which there flows a kind of Oyl of the Marrow, (of which mention has been made above) and from others a tough slimy Humour (which Dr. *Havers*, the Discoverer thereof, calls the *Mucilago*) into the Joints, between the two Cartilages that rub upon each other. And the said Author shews by Experience, that it is not without just Cause that he names them Watry Humours, because he proves, that after the Evaporation of the Water, there does hardly remain the thirtieth Part of that Matter.

Once again, I say, let such an unhappy Infidel betake himself to some Retirement, where he need not be affected with the Shame of Recanting those Erroneous Opinions, which he has so long and so boldly maintained, and consider, whether he can believe, since this Mucilaginous and Watry Humour, is of so great Service, that all this *Apparatus* of so many Glands as are found in the Joints, and which, being compressed by the Motion of the Bones, do, like squeez'd Spunges, yield this Moisture; I say, whether such a Disposition can be made without any determinate End. And, on the contrary, whether he does not plainly discover therein, the Wisdom and Designs of the Creator.

As *first*, that these Glands (some of which being taken out of the Joint of the Elbow, are of the Form represented in *Tab. IX. Fig. 6.* and others lying by the Knee-pan *C*, taken out of the Knee at *aaa*, *Fig. 7.* with the Membrane *bbbb*) placed in such a manner, as not to receive any Prejudice by the pressing of the Bones; for which purpose, the Great Creator has prepared for them a Cavity, which encompasses and secures them against any rubbing or breaking in great Motions and other Cases,

Cases. *Secondly*, However in such a manner, that when there are great Inflections and much Work to be done by the Joints, they may be softly compressed to make them render their Liquor more freely, of which a greater Quantity is then wanted; and when the Joints are at rest, these Glands may preserve more of it in them, and not shed it in vain. Those who desire a more exact Account hereof, founded upon several Experimental Discoveries, may have recourse to the above-mention'd Treatise, from pag. 227. to p. 232.

SECT. XVII. *Convictions from the foregoing Observations.*

NOW how many Convictions of the Wisdom and Goodness of GOD, may be deduced from this Description of the Marrow, and Structure of the Glands, may be learned from the aforesaid Author, pag. 238. whose Words are as follows; *And here we cannot forbear to observe the visible and palpable Tokens and Footsteps of an Infinite Reason, which, as they are deeply engraven upon the Universe in general, are yet so in a much more particular manner in this wise Disposition of Motion in Animals. Nor can we ever sufficiently admire the Wisdom and Providence of our Great Creator, who has communicated to all the Parts of these Beings, not only such a Composition, by which all the necessary Motions and Operations, requisite in them, are conveniently produced; but has moreover endowed them with such Advantages and Privileges, whereby they can both maintain themselves, and discharge their proper Functions in the most easie manner.*



CONTEMPLATION XII.

Of the Sight.

SECT. I. *Transition to the Sight.*

WE proceed now to the External Senses, and among them to observe in the first Place the Instruments of Sight; where it must needs appear incredible to every one, that such a Number of Particulars and Circumstances, as are requisite in so great a Matter as that of the Sight, should have concurred and met each other in so small a Compass as the Space that contains the Eye, by mere Chance, or necessary Causes, without the least View or Intention of the Creator.

To give therefore a Brief Account of the External Disposition of the Eye: Can it be thought to happen without Design?

SECT. II. *The External Structure of the Eye.*

I. THAT because the Eye is so tender as to be hurt by the least Accident whatever, the Eye-lid may, like a Curtain, be drawn over it with unconceivable Swiftneſs upon the approach of any Danger, for the Security thereof; and at the time of Sleep, to hinder the Action of Light upon it to the breaking of that Rest which is so necessary to it. And again, that with the same Swiftneſs for the Admission of Light, the Eye-lid can be lifted up and folded together, for which End it is provided with particular Muscles.

2. To

2. To the end, that the Eye-lids may not hang loose and flabby upon the Eyes, and that their Motion may be the swifter, they are provided with a Cartilaginous Bow, which is accurately and nicely adapted to the Convexity of the Eye.

3. That the Eye is encompassed on all sides by Bones, to defend it from all outward Harms: Forasmuch as by the least pressure the Figure of it would be changed, and (not to mention the Pain or Smart) the Sight would be greatly disorder'd. If any body doubts of this, let a Man shut one of his Eyes, and press the other gently with his Finger, and he will presently be convinced of this Truth by the different Appearance of visible Objects.

4. The Structure of the Eye-brows, which are provided with Hair, to prevent the descending Sweat of the Forehead from running into the Eyes.

5. To the end that the external Membrane of the Eyes may not be dried up, and wrinkled by the Air, and so not only the Motions of the Eye-lids, but likewise the Sight itself obstructed, that there are Glands placed in one Corner of the Eye, and over it, which by several little Tubes, shed a continual Moisture upon the Eye, to make it smooth, and to secure the Membranes from too great a Dryness.

6. And to the end that the Countenance should not always appear Weeping and cover'd with Tears, that there are Passages contrived, by which this Humour at the usual Times can be discharged into the Nostrils. And the same Humour in extraordinary Occasions, being changed into a flood of Tears, we are then much more sensible of the Course of them into the Nostrils.

7. To the end that we may not be obliged continually to turn the Head to different Objects, there are different Muscles fasten'd to the Eye, that in

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an instant of Time do suffice to turn it on all Sides.

8. That no part of this Muscular Structure should be in vain, the Eye is made in a manner Globular, to turn indifferently in a Cavity adapted to it; the back Part of which is lined with Fat, to render the Motion smoother and quicker.

SECT. III. *Convictions from what has been said.*

How small soever these little Circumstances may appear to some People, and as little beholden as an unhappy Philosopher may think himself to his Master, while he ascribes all to meer Chance, or Ignorant Causes; yet if he should happen to be depriv'd of the use of any one of them, he would soon be sensible of the Inconveniences thereof: And tho' perhaps he might still continue so obdurate, as not to own the Goodness of God in bestowing them; yet if he were not quite divested of Reason, he would be convinced, that he should owe a great many Thanks to any Body that restored it to him, as soon as he felt the want thereof.

With much Compassion as well as Astonishment at the Goodness of our Loving Creator, have I consider'd the sad State of a certain Gentleman, who, as to the rest, was in pretty good Health, but only wanted the use of those two little Muscles that serve to lift up the Eye-lid, and so had almost lost the use of his Sight, being forced, as long as this Defect lasted, to shove up his Eye-lids, every moment, with his own Hands.

If it be owing to Chance that such small Muscles as these are fixed in those Parts: How comes it, since so many Things must concur to their Motion, that we don't meet with such Defects in Millions of other Men? Since Chance does as easily produce the one effect as the other; and since there
be

be Millions of Ways in which the Particles that compose the texture of such Muscles might concur; among which however, there would not be one that could dispose and adapt them to such uses.

Would an Atheist venture to affirm that the simple Pullies made use of to raise Sash-windows, had acquired their Aptitude for that purpose by meer Chance?

SECT. IV. *The Properties of Light.*

IF all this be not sufficient to convince the most obdurate Atheist, let him go on to contemplate with us that which follows, and we do not question, but he will be forced to own, that the most secret Laws of Opticks and Mathematicks must have been known to him that formed the Eye, before He could have produced such a wonderful Machine.

Now it will be necessary to shew some of the Properties of Light, to such as are unexperienced in the afore said Sciences; to the End, that they may have a tolerably clear Conception thereof: It is therefore well known:

1. That the Light, either of the Sun or of a Candle *K*, (*Tab. X. Fig. 1.*) to give an Example thereof) falling upon the extream Part or Point of a Needle, renders the same visible to an Eye at *CCC*, &c. and *R*, wherever it be. So that it appears from thence, that the Light diffuses its Beams, *PC*, *PC*, &c. Spherically, or like a round Ball towards all sides; and therefore, that in the whole upper Superficies of the said Ball, as *C*, *C*, *C*, *R*, &c. no Point can be taken, to which some Ray, as *PC*, is not extended, supposing the Eye at any of the Points, *C*, *C*, *C*, &c. or where-ever else it is placed in that Sphere.

And that this is each time performed in a strait Line, may be observed from hence, that a dark Body *S*, placed between the Eye at *R*, and the Point *P*, in the Right Line *PR*, hinders the Eye from seeing the said Point *P*.

2. This continual Scattering or Separation of the Rays, *PC*, *PC*, &c. from each other, is called *Diverging*: And thus we see, that all the Rays of Light *PC*, *PC*, &c. with respect to one another, when they proceed from the said Point *P*, are what the Learned call *Divergent*; as on the contrary, those Rays, for instance, that flow from several Points, *CC*, &c. and by the help of Burning-Glasses, or other Optical Methods, are compelled to run into a Point *P*, are called *Convergent*.

3. It follows from this Divergency (*Tab. X. Fig. 3.*) that if from all the Points, as *A*, *N*, *L*, *M*, *B*, of the Line *AB*, (or rather from so many as there may be in the whole Line *AB*) the Rays fall upon another Line *ST*; the Rays flowing from all the Points of *AB*, to each and singular Point of the Line *ST*, cannot be extended without an apparently great Confusion.

4. Wherefore, in case the Rays *Diverging* after this manner, should fall directly upon that Part of the Eye where the Sight is to be formed, the Rays proceeding from each Point of the visible Object *AB*, would sufficiently fill the whole Superficies of the Place, and fall into great Confusion among one another, as may be seen at *S*, *T*, *O*.

5. Now 'tis a known Law of Opticks, that in order to see an Object distinctly, all the Rays coming from a Point thereof (as from *B* for instance) must be collected at the Bottom of the Eye in a Point *b* (and so such as come from *A*, and other Points of the said Object, in so many other Points again, as *a*, &c.) thus forming upon the Bottom of the Eye at *ab*, the Picture or Image of
of

of the Object *AB*; but inverted, or upside down.

6. Now since this cannot happen unless the Rays, which, according to the Natural Course of Light, proceed from the Point *B* *divergently*, or wider from each other, are again made *Convergent* at the Point *b*, it has pleased the Great Creator to determine the Motion of Light, with respect to the *Medium*, or Matter thro' which it passes, by other Laws, by which He brings this great End to pass.

SECT. V. *Concerning Refraction or Breaking of the Rays.*

THESE Laws are those which in Opticks are known by the Name of *Refraction* (that is the *breaking*, or rather the bending of the Rays of Light) and the Appearances thereof are as follows;

1. When Rays pass from one Medium or Transparent Matter, such as the Air, for instance, into another, as Water, Glass, Chrystal and the like, whether it be denser or rarer.

2. When they fall upon the latter with any Obliquity; for if they fall at Right Angles, or Perpendicularly, We find they pass directly through, and are not broken, or bent at all.

SECT. VI. *An Experiment of Rays passing from Air into Water.*

IF you desire to see this experimentally, set a Candle in a dark Room (*Tab. X. Fig. 2.*) upon a Table, and an empty white Bason *NKLM*, at a little Distance from it, in such a manner that the Shadow of the Brim *ML*, of this Bason, may extend itself from *M* to *D*; when it will appear, that the Ray *AMD*, which separates the Shadow at *D* from the Light, is the last Ray that falls

falls on the enlighten'd inward Part of the Bason-place *N B D*.

Then lay a shining piece of Money *E* (for instance a Shilling) just within the Shade, so that the Edge of it may approach very near to *D*; you must take care next to fix that piece of Money in such a manner, that it may not remove from its Place; and lastly, fill the Bason up to *B C* with Water; then you will find that the Shadow will not extend itself farther than to *F*, and the Shilling *E* will lye out of it in a perfect Light: So that now *HF* is the last Ray that separates the Light from the Shadow.

Now it is plain, that from *A* to *F* there can come no direct Ray *AF*, because it is stopt by the Bason at *P*.

And yet you see the Light proceeding from *A* to *F*.

From whence it follows, that as the Ray moved directly in the Air from *A* to *H*, instead of proceeding strait forwards to *D*, it is broken and bent, and makes an Angle *AHF*, at the Superficies of the Water *H*, and so runs from *H* to *F*.

And thus you have an Example, how a Ray *AH*, passing thro' a thinner Medium, such as Air, into a thicker, as Water, is *Refracted* or Broken; and in such a manner as to bend towards the Perpendicular Line *GHQ*, which makes a Right Angle upon the Superficies *BC*, where the different Mediums of Air and Water are separated from each other.

S E C T. VII. *An Experiment of the Refraction of Rays passing from Water into Air.*

NOW to shew the Appearances of a Ray passing from a denser or thicker Medium, to a rarer or thinner, as from Water to Air:

Lay

Lay the said Shilling E , in an empty Vessel NK LM , (*Tab. X. Fig. 4.*) so that one who stands at AS , may be just hinder'd by the Brim of the Vessel TM , from seeing the Money at E : Forasmuch as from E to the Eye A , no direct Ray AE can proceed, by reason of the Interposition of the said Brim ML .

Then fixing the piece of Money E , to the Bottom of the Vessel in such a manner, that it may not be removed by pouring in the Water, let there be Water poured into the Vessel as high as BC : Whereupon he that stood at AS , and could not see the Shilling before, will perceive it very clearly, as if it was at F .

Now it is plain from all this, that the Money really lay at E , and that it could not be seen by any direct Ray EA .

And yet it was clearly seen at F .

From whence it follows, that it must have been seen by the Refraction, or bending of the Ray EH , which, instead of running directly to T , makes the Angle EHA , and so reaches the Eye A .

Which (because we are wont to imagine that we see nothing but what lies in a right Line, extended from our Eye to the Object) sees this piece of Money as if it lay at F .

And to prove that it only happens thus by the aforesaid Refraction, let another Person be placed at IO , whose Eye I , is not able to see the Money E , while it lies in the empty Vessel, the Rim of which, NK , intercepts the direct Ray IE ; and yet when the Water is poured into it, he will see the same lying at P , by the help of the Ray ERI , refracted at R : So that the said Money will appear to the Eye A , removed from E to F , but to the Eye I , removed from E to P ; and thus two Contradictory Motions will be produced: And in like manner, if there were a whole ring of Spectators a-

bout the Vessel, each one would see the Object in a different Place.

From hence it appears, that a Ray, EH , is refracted in passing from a denser Body, as from Water, into a rarer, as Air; and that it does not run directly from H to T , but to A , and so is somewhat inflected from the Perpendicular Line GH 2.

SECT. VIII. *An Experiment shewing that Rays falling at Right Angles are not Refracted.*

IT is likewise plain, that a Ray falling perpendicularly from one Transparent Medium to another, suffers no Refraction, (as the afore-mention'd Ray did, which came upon it obliquely) if you look upon the aforesaid piece of Money E , lying in an empty Vessel, thro' a Narrow and Perpendicular Tube DV , whilst it lies directly under it; after which, fill the said Vessel, with Water up to BC , taking care that the Money remain in the same Place, and the Tube in the said Position, thro' which the Money will be seen just as it was before. Whereas, if you look at it thro' the Tube lying obliquely in the Position HT , the Money will not be seen at E , as in the empty Vessel; for-much as, in order to see it again after the Water is poured into the Vessel, the Tube must be brought down from HT to HA , by reason of the Refraction of the Rays: This is what every one may try, as well as we.

SECT. IX. *Divergent Rays made Convergent, and form an inverted Image.*

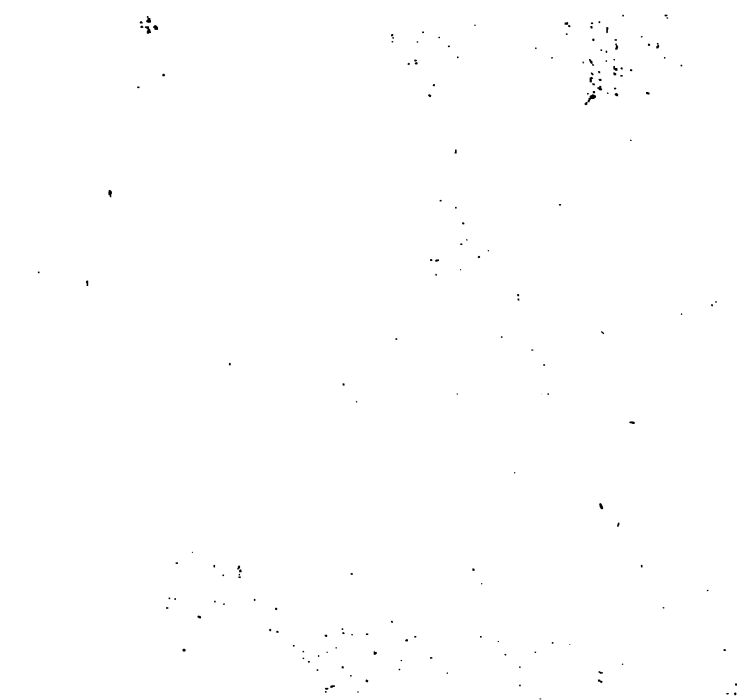
FROM these two Laws there does now follow a General Rule, which, as appears by innumerable Experiments, is always observable in the Motion of the Light, viz. that (*Tab. XI. Fig. 1.*) the Rays

BH ,
 H

finning p

Fig. 5





B H, B H, Diverging from a Point *B*, may, by Refraction, be inflected towards each other, and become again *Convergent* in a Point *b*.

1. When they pass from a rarer Body into a denser, which is Convex and Spherical; and, 2. When they fall upon an Object of the like Figure, from a thicker to a thinner Medium.

For instance, let *K F* be a Glass polish'd on both sides, and each side of *K M F* and *K N F* be Convex and Spherical: Now when the Ray *B H* comes upon it from the Air, it will not proceed to *R*, but be inflected towards the Perpendicular *G H*, and take its way according to *H P*; but in passing from the said Glass *P*, into the Air, it will not proceed to *S*, according to *H P*, but receding from the Perpendicular Line *P Q*, pursue its way to *b*.

And this happening to all the Rays, which fall from *B* upon the Glass between *H H*, they will all be united again about the same place at *b*, only the middle Ray, *B M N b*, because it falls every time perpendicularly upon the Glass, runs directly forward, and without being refracted.

So that in case we suppose (*Tab. X. Fig. 3.*) that at *S T*, a Glass is so placed, as that the Rays passing from *A* to *a*, from *B* to *b*, and from the other Points *N, L, M*, to *n, l, m*, be united together, they will make at *b a* an inverted Image *A B*.

SECT. X. *An Experiment shewing the same.*

LET those who have a mind to see a very easie Experiment hereof, place one single Candle in a Chamber at Night, and retiring some Distance from it, let them cause its Light to pass thro' a Spectacle Glass upon a white Paper: Whereupon, having likewise adjusted the Distance between the Glass and the Paper, they will see the exact Picture of a Candle inverted upon the said Paper.

That is, at the place *b a*, where all the Rays coming from each of the Points of the Candle, at *A B*, are collected in so many other Points by the two Refractions, which (as in *Tab. XI. Fig. 1.*) they suffer thro' the Spectacle or Burning-Glass, convex on both sides, and so form the above-mention'd Image.

SECT. XI. *A Second Experiment in a dark Chamber.*

THERE is another way of proving the same by the famous Experiment of a *dark Chamber*, which is made thus: You must make the Chamber as dark as you can, leaving a round Hole in a Window, something smaller than the Circumference of a Spectacle Glass; then place such a Glass exactly before the Hole, taking care that the Light has no other Passage into the Room.

Now if you hang a white Cloth or Paper at a proper distance before the said Glass, so that the Rays that proceed from every Point of the Objects may each of them be collected in its correspondent Point, you will perceive that the Images of every Thing that is without the Chamber will be painted in the most perfect manner, upon the said Cloth or Paper, according to all its Lineaments and Colours, especially if the Sun happen to shine upon the External Objects, and the Glass be in the Shade; as it may when, for instance, the Sun is in the South, and the Window, in which the Glass is, stands towards the North, so that none of the Sun's Rays come directly upon it.

SECT. XII. *Convictions from the foregoing Observations.*

NOW since it is the Property of Rays that proceed from a Point, to be diverged and scattered from

from each other, and that they must be made to converge or be united in a Point again, in order to form the Picture of an Object, and thereby to make us see it distinctly: Can it be conceived that all these Laws concerning Light, all this Disposition made in the Eye (how small soever it may appear to an Ignorant Person) and all the other necessary Circumstances observed therein; I say, can it be thought that all these Things have concurred in so little a space, as that wherein the Eye is placed, without any Design or Wisdom of the Creator?

SECT. XIII. *The Eye is a Dark Chamber.*

NOW to represent this Matter to every one's entire Satisfaction, and to convince him, that the Images of visible Objects are really painted upon the Bottom of the Eye by the Light, after the same manner as in the above-mention'd dark Chamber by a Convex Glass; He need only take (thus I find the Experiment to have been made in the Year 1696.) the Eye of a newly killed Ox, while it is warm, (see *Tab. XI. Fig. 2. C G E H*) after having divested it of its Flesh and Fat, and left nothing remaining but the Membranes and Optick Nerve; then about *b* or *a*, behind in the Eye, let there be a small hole made with the point of a sharp Knife, in the Membrane in which it is involved; and moreover a little round piece, of about a Finger's breadth, cut out with fine-pointed Scissors, leaving it fasten'd only at *X*, so that the Eye may be held by the Part here represented at *X t*, and so the Orifice *CCN* directed which way one pleases.

Then placing the Flame of one Candle only, lighted for that purpose in a dark Room, before the Eye at *AB*, you shall see the exact Picture of the same, inverted very plainly at *ab*, and represented burning upside down. But

But that this Experiment may be made as it ought to be, care should be taken not to hurt a very fine and tender Membrane, including the Vitreous Humour behind at *ab*: For whereas you otherwise see the said Humour itself transparent and naked, some Light may perhaps appear, but the Image will not be so well represented.

However, upon such an Occasion, which easily happens, one may cover the naked Vitreous Humour behind at *ab*, with a very fine white Paper; by which means you will see the exact Form and Motion of the Flame, and also the Top of the Candle itself, accurately drawn upon it.

It is more convenient to try the Experiment after this manner, than to place the Eye before the Hole of a dark Chamber, in order to admit thereby the Images of the External Objects: It is likewise performed this way with much less trouble.

For one may easily see this way, 1. That the Eye being brought nearer to the Candle, the Picture is drawn sensibly larger; and if removed farther from it, it becomes smaller again. 2. That upon moving the Candle towards the Right, or Left Hand, the Picture goes in a direct contrary Motion.

From whence it seems probable, that our great Creator makes use of these Means, to the end, that by increasing, or lessening the Images formed in the Eye, we may judge of the Distance of Objects by their apparent Greatness, or of their Greatness by their apparent Distance; as He likewise makes known to us the Motion of Things that are remote from us, by the Motion of their Images.

For that these Images are not formed in the Eye, without making some Impression upon the Membranes thereof, seems deducible from what a Man feels, who has been any time in the Dark, when he suddenly returns into a great Light, and opens his Eyes to look about him, S P C T.

SECT. XIV. *No Images by Divergent Rays.*

HAVING thus far shewn that our Eye is a real dark Chamber, this Truth does likewise occur to us, namely, that such Images of an Object *AB*, cannot be formed upon the Bottom of the Eye at *ab*, by Rays, which, for instance, flow from the Point *B*, so long as they are *Divergent*, as at *BC*, *BC*; but that it is absolutely necessary for that purpose, that they should be bent again towards each other by Refraction, in order to be collected into a Point *b*, and there to form the Image.

SECT. XV. *The Transparency of the Tunica Cornea.*

NOW to represent only some few of those Circumstances, which may serve for Conviction, without embarrassing a Reader not well skilled in Anatomy with a Number of differing Names given by the Learned to the Membranes of the Eye, of which some Anatomists reckon only three, others 4, 5, 6, 7, yea, 8 and 9, as you may see in *Verheyen*; Let us suppose the little Globular Body, *GCH E* (*Tab. XI. Fig. 2.*) to be the Eye.

Now no Body will contest with us,

First, That in case all the Membranes which encompass the Eye were opaque, as well as those that are in the other Parts of the Body, by reason of their want of Transparency; the Light would be able to get little or no access to the Eye.

Can it be then supposed to be without Design, that notwithstanding that the whole Eye is encompassed round about with an untransparent Membrane *GEH* (which shews itself likewise externally, as the *White* of the Eye) yet, at that place where the Light falls upon it, at *NCC*, there should be found a spherical, thin, bright, and very transparent

rent Membrane, such as the clearest Horn or Glass is, in order to afford a Passage to the Light; and which is therefore called the *Tunica Cornea*, or Horny Membrane?

SECT. XVI. *The Aqueous Humour.*

Secondly, Now in case the Rays of Light, *BC*, *BC*, coming out of the Air, and from the Point *B* (for example) and having passed thro' this Membrane *GNCH*, should again meet with the same Air placed in the Cavity of the Eye, *GSDTHCG*; as it happens in the Cavities of the Ear, where such Air is necessary, they would proceed to diverge or separate themselves from each other, and so be unable to form an Image at *b*, which is requisite in order to see the Point *B* distinctly; Will any one again pretend, that it is without Wisdom and Design, that this space *GSDTHCG* is filled with a Liquor that has all the necessary Qualifications in it, *viz.* that it is, *First*, entirely Clear and Transparent for the Reception of *Vision*; *Secondly*, that it is thicker than Air, and about the Substance of Water, for which reason 'tis called the *Aqueous* or *Watry Humour*; *Thirdly*, that it is convexly round, as appears by the external Figure of the Eye; from whence it is plain, that both the Rays, *BC*, *BC*, divergent from *B*, cannot proceed forwards to *gg*; but by the Laws of Refraction, must be inflected towards each other, and pursue their way to *DD*, according to the Lines *CD*, *CD*?

SECT. XVII. *Crystalline Humour.*

Thirdly, Now if we should suppose that these Rays, according to *CD*, *CD*, should again proceed directly to *dd*, we should at the same time find,

find, that they would either not at all run into a Point, or at least into such a one as lies very far behind the Eye.

From whence it follows, that there must be a new Refraction to inflect them again towards each other, in order to make them meet at *b*, or in a much nearer Point.

Now, in order to make this happen very exactly, another Body, *STDES*, must come after; which is, *first*, Transparent, *secondly*, Thicker than the Aqueous Humour, and, *thirdly*, in some measure Convex.

And here again, we find all these required Circumstances to happen in such a manner; for the very opening of an Eye, may convince every Body, that the following Humour *STDES*, is not only clear, but likewise of a thicker Substance than the *Aqueous*, for which reason 'tis called the *Chrystalline*, and represents rather a solid Body than a fluid, and, which is yet more, it is Convex at *SDDT*.

These are therefore the Means that hinder the Rays proceeding, as *CD*, *CD*, from passing on directly to *dd*, and force them, according to the Laws of Refraction, to inflect themselves a second time towards each other, and to take their way to *DE*, *DE*.

SECT. XVIII. *The Vitreous Humour.*

Fourthly, AGAIN, if these Rays had pursued their Course strait forwards to *ee*, they would indeed have met again at the Point *k*, but that would have been too far behind the Eye; and they falling upon the Bottom of the Eye, would have taken up too much room at *mn*; and the single Point of the Object *B*, would have been here represented with a great Superficies, *mn*, which happening thus thro' all

all the Points of the Object AB , the Rays of several different Points lying near each other, would have struck the Bottom of the Eye in the same place, and so have produced a confused Image, and therefore confused Vision.

He that does not conceive this easily, may represent to himself, first, with a proper Exactness by the help of a Convex Glass, placed at ST , in a dark Chamber, (*Tab. X. Fig. 3.*) the Picture ab , of an Object AB upon a white Paper rs ; and then removing the Paper from rs to pg , or nearer to the Glass ST , he will perceive the Confusion of the Picture, for the Reasons that have been just alleged.

Therefore to prevent this in the Eye (*Tab. XI. Fig. 2.*) it was necessary, that a second Refraction should be made, whereby the Rays might be collected at the Point b , instead of the Point k .

That this may happen after the best and most useful Manner, the *Crystalline Humour* ST , must be again Convex at SET , and that which follows at $SGRHTES$, thinner of Matter, and likewise transparent.

Now all these Particulars do occur here again; since the *Crystalline Humour* (as you may observe, if you take it out of the Eye) is not only Convex behind at SET , but much more so than in the forepart of it $SDDT$; the whole Cavity also of the Eye $SGRHTES$, behind the *Crystalline Humour* ST , is quite full of a very clear and bright Humour, about the Consistence of melted Glass, or, according to others, of the White of an Egg; at least, it is of a thinner Substance (which is necessary here) than the *Crystalline Humour*, and therefore 'tis called the *Vitreous Humour*: This being so, they that understand the foregoing, must likewise know that the Rays coming from DE , can't pass directly thro' e to k , but being again broken at E , must
be

be bent towards each other, and pursuing their way according to $E b$, $E b$, must be united at b .

SECT. XIX. *How the Image is formed in the Eye, and Conclusions from the foregoing Observations.*

Fifthly, HAVING thus shewn, how the Rays, diverging from the Point B of the Object AB , must meet at the Bottom of the Eye in a Point b ; if you suppose that those Rays which come from every other Point of AB , are likewise after the same manner collected in a visible Point of ab , you will also see after what manner the above-mentioned Images are formed by the Light, upon the Bottom of the Eye, as it were in a dark Chamber.

Now can any Thing more be required by those who sincerely search after Truth, towards a Proof of the Wisdom of the Creator, than this wonderful Structure of the Eye, and these Inflections of the Rays repeated three times after one another; which, if they had been otherwise scatter'd or separated, would not only have been unfit in their own Nature, by reason of such Divergency, to have formed an exact Image; but even produced a Motion which would have been directly opposite to what the *Sight* required?

SECT. XX. *Several Remarks; First, that the Eye is Black within.*

WE might make innumerable Observations upon the wonderful Things that are to be found in the Eye; as, 1. That the Eye must be dark within, in order to represent the Images as strongly as is done in a dark Chamber, and is it not so? Even so far, that its Membranes or Tunicks, are in a great measure, and for this very purpose, of a Blackish Colour: Can so necessary a Quality as this result from Chance?

SECT.

S E C T. XXI. *The Second Remark ; That the Chryſtalline Humour is a Microſcope : And Convictions from thence.*

2. T O the end, that the Images ſhould be nice and accurate, ought there not to be in the Eye a transparent Body, Convex on both ſides, and the moſt Convex-part undermoſt ? And do not both theſe Qualities occur in the *Chryſtalline Humour*, which has the form of a poliſhed ſpherical Glaſs before and behind, as likewise all its Properties ?

For, if you take this Humour out of the Eye of a newly killed Beaſt, and hold it before a burning Candle, and a piece of white Paper behind it, you will ſee upon the Paper as exact an Image of the Flame inverted, as if the ſame were projected or made by a Glaſs : Or place the ſame before your Eye, and the Head of a Pin, or any other little Thing, cloſe behind it, and if you look thro' it, you will ſee the very ſame Appearances as thro' a real Microſcope, which is likewise made Convex on both ſides for the ſame purpoſe.

Did ever any one pretend to ſay, that a good Microſcope had acquired its Figure, its Transparency out of a dark Matter, and its Diſpoſition of being ſo uſeful, without any Deſign of the Perſon that made it ? How therefore can it be aſſerted of this Humour, where all thoſe Qualities are found in a more eminent manner ? Or could the beſt Artificer in the World produce ſuch a Thing from Bread, Fleſh, Fiſh, and other Food ? Can then an unhappy Philoſopher diſcover neither Art nor Knowledge therein, after having obſerved the like Appearances, not once only (which might have happen'd by chance) but in ſo many Millions of Eyes, both of Men and Beaſts ?

§ E C T. XXII. *The Third Remark, upon seeing at several Distances: An Experiment thereupon.*

3. ONE may yet farther see by the Experiment in a dark Chamber, that the Distance of the Object *AB* (*Tab. X. Fig. 3.*) from the Paper *rs*, and from the Glass *ST*, ought to be certain and limited, to form a distinct Image at *ab*: So that the Paper being held at *pq*, nearer to the Glass *ST*, or at *de*, farther from the said Glass, if the Object *AB*, and the Glass *ST*, remain in their place, the Image will be very confused; because the Rays coming from each of the Points *A* and *B*, are not collected in the Point *a* and *b*, but instead thereof, fill a great space at *p* and *q*, or *d* and *e*; so that those which proceed from different Points must thereby be mix'd together and confused.

From whence it appears, that no Images can be rightly and truly formed, when the Collection of the Rays that come from *A* or *B*, are made at *a* or *b*; the place of Collection *ab*, being either before the Paper, which is then at *de*, or behind the Paper, when at *pq*.

Again, we likewise see, if the Object *AB* is farther from the Glass *ST*, or the Glass itself is rounder than at the time when a distinct Image was formed thro' both of them at *ab*, the exact Image will fall closer to the Glass, as for instance, at *pq*; and therefore the Paper must, for this reason, be brought forwards from *rs* to *pq*, and nearer to the Glass.

The contrary happens, if the Object *AB*, be brought closer to the Glass *ST*, or if the said Glass be not so Convex, as we at first supposed it; for then the exact Image will not be found, unless the Paper be removed backwards to *de*, and the Distance thereof from the Glass rendered greater.

Now, notwithstanding that all these Things come to pass in our Eyes, yet would our Sight, for all this great *Apparatus*, be of little use, and wholly imperfect, with respect to the Objects that are near us: So that, for instance, one who sees an Object distinctly at the Distance of a Yard, would not be able to distinguish the same, either at the Distance of half a Yard, or a Yard and half, or any other-wise, farther or nearer, unless the means above-mention'd were used in the Chamber of our Eye, *viz.* either by making the Roundness of one of the Humours more or less Convex, or the Distance between the *Chryselline* Humour, and the Bottom of the Eye (which supplies the place of the Paper) greater or smaller, according as the nearness or remoteness of the Object requires it.

If this should not be sufficiently intelligible to one that has not been versed in Optical Experiments, let him in a dark Chamber make use of a flatter or more convex Glas; or, to speak in the Language of the Glas-Grinders, of younger or older Spectacles, and of a greater or smaller Distance of the Object; and Experience, after a little attention, will render the Thing plain enough to him.

Now, to apply all this to the purpose; Can any one, without being astonish'd at the Wisdom and Goodness of his adorable Creator, observe, that not only one of these means (which was enough alone) but both together are found in the Eyes? For when an Object is far from the Eye, and therefore (*Tab. XI. Fig. 2.*) the Point *a* or *b* (where the Rays proceeding from a Point *A* or *B* converge, or are gather'd together) does not reach the Bottom of the Eye *Xm*, but falls nearer to the *Chryselline* Humour *ST*; a confus'd Image, as has been said before, would thereby be formed at the Bottom of the Eye, but no distinct Vision; so, that to prevent the same, it is necessary that the Distance between
the

the Bottom of the Eye Xm , and the *Chrystalline Humour* ST , should be smaller; or (if the Distance between them remain as it was) one of the Humours of the Eye should be render'd less Convex, to cause the Image to fall farther, viz. at ab .

Now we find that to bring both these Things about together, the four Muscles of the Eye, EF GH (*Tab. X. Fig. 5.*) seem to be necessary to move the same (as any one of them is contracted, and so made shorter than the rest) upwards and downwards, and to the right and left; and when they act altogether they draw the fore-part of the Eye, as likewise the *Chrystalline Humour* backwards, diminishing in such manner the distance between it and the Bottom of the Eye; but particularly, it is likewise plain, that they make the external Figure of the Eye, which is very Convex and Globular, much flatter, and so cause the collected Rays to fall more backward, in order to reach the Bottom of the Eye.

Now that the Rays coming from an Object, and falling upon a flatter Glass, do paint the Image further backwards than when the Glass is more Convex, has been already shewn in the Experiment of a dark Chamber.

Now if the Object (*Tab. XI. Fig. 2.*) be too near the Eye, and the Collection of the Rays coming from the Point B , does not happen upon b , but upon k , behind the Bottom of the Eye Xm ; it is plain enough, that to prevent it, the contrary must be effected, namely, that the space between the *Chrystalline Humour*, and the Bottom of the Eye Xm , should be greater; or (the space remaining the same) the *Aqueous Humour* of the Eye at Mcc somewhat rounder.

For that a rounder Glass forms the Image shorter and nearer to itself, may be experimentally proved with great ease in a dark Chamber.

Now to perform both these Operations at the same time, the Anatomists produce two Muscles at *INKM* (*Tab. X. Fig. 5.*) which they call oblique Muscles; and which, when contracted, do each of them draw the Eye on its side, but when they work together, they draw the Eye as it were with a Girt- ing Rope, and swelling up, press it on all sides; by which means the *Aqueous Humour* being made protuberant, the Eye becomes rounder at *NCC* (*Tab. XI. Fig. 2.*) and the *Vitreous Humour* being pressed backwards, the Distance between the Bottom of the Eye and the *Crystalline Humour* is render'd greater.

I know very well, that some Learned Gentlemen do not think that the peculiar Use of these Muscles, for this purpose, is yet fully ascertained, till it has been further proved; but we shall let ourselves into this Dispute at present no more, than we shall enquire whether those only have hit upon the Truth, who maintain, that the Fibres *GS* and *HT* (which the Anatomists call *Processus Ciliares*) have a quality of causing the *Crystalline Humour* itself (whenever it is necessary) either to change its Figure, that is to say, rendering it more or less Convex; or of bringing it nearer and removing it farther from the Bottom of the Eye.

However, the one or the other of the Operations above-mentioned, seems to be experimentally felt in the Uneasiness, or sometimes even in the Pain, which the Eye suffers, when we use any Force to see an Object that is far from the Eye distinctly, or to read a Writing a little too near.

But this is incontestably true, that the Eye does something in the viewing of Things that are placed at several Distances from it, without any Concurrence or Knowledge on our part, which the greatest Mathematicians have not yet been able to bring about by their Instruments of seeing; the Disposition

tion of which, as the distance of an Object is sensibly greater or smaller, must likewise be alter'd. And this is sufficient to convince us (tho' we know nothing of the manner how it happens) that there is a G O D, by whom we are made, and who had a wise End and Design in forming the Eye, as it here appears.

SECT. XXIII. *The Fourth Remark, upon the Opening and Shutting the Black of the Eye or Pupil, with an Experiment proving the same.*

Fourthly, IF this great and wonderful Structure of the Eye, by which we are enabled to see so easily and distinctly, at so many and such different Distances, be not yet sufficient to convince a Sceptical Enquirer of the Wisdom of his Creator; let him proceed further, and in the last place (since, if we should take notice of every Thing concerning the Eye, this alone would require a whole Book) to contemplate with us that which follows:

First, That if the Hole in a dark Chamber be made so small as to admit but too few of the Rays, the external Images would be represented imperfectly without the necessary Force and Liveliness.

Secondly, If the Hole be so great as to admit of the Entrance of too much Light, the Images would appear yet more weak and imperfect for other Reasons. So that there is an exact Proportion required for that Hole or Space, thro' which the Rays are to pass, to the end that every Thing may have its proper Energy; and that the number of the Rays be neither too great nor too small: And how much trouble the finding the just Proportion of such Holes or Openings occasions to those who make Telescopes, Microscopes, and other Instruments for seeing, is but too well known by those that have had the trial of it.

The same Thing happens to the Eye, as being a *dark Chamber*; and it is easie to discover experimentally, that too few Rays render the Sight of an Object weak, if you make a Hole with a Pin in a white Paper, which Hole shall be much smaller than the little black Circle of the Eye, called in *Latin*, the *Pupilla*; and thro' which the Rays of the Object are admitted into the Eye.

Now when you look thro' the said little Hole (especially in a place where the Light is not too strong) upon a piece of Marbled Paper, in which there are a great many Colours, it is well known, that if it be held close to the Eye, there can come no Rays from it but thro' the aforesaid little Hole; and that therefore the number of them is much fewer than if they were immediately received in a greater Opening of the *Pupilla* without this Hole: But we shall likewise find at the same time, that the Colours of the Marble Paper will shew themselves much fainter and darker thro' the little Hole, than they would directly to the naked Eye.

Now in case this Pupil, being too large, should admit too many Rays, as it does when one passes suddenly from a very dark Place into a clear and strong Light; we find likewise, that upon this account, the Action of *Seeing* becomes very troublesome.

Now to produce again a Proof of God's wonderful Wisdom and Mercy from this last Instance, Could any Body reasonably suppose, that what is done herein, with so much trouble by the Artificers in their Optical Instruments, is performed by the Eye of itself, and without the Direction of the great Creator, and even without the Knowledge of the Man himself in whom it happens? And moreover, after such a manner as infinitely exceeds the finest Machine that Human Art has ever yet brought to the highest degree of Perfection?

Thus

Thus we see that the Passage *FF* (*Tab. XI. Fig. 2.*) thro' which the Rays of Light go, or rather that black little Circle in the Membrane (according to which our Eyes are denominated Black, Grey, or any other Colour) commonly called, the *Black or Apple of the Eye*, becomes in a healthy Man smaller in a great Light, and immediately greater in a small Light; in order to admit more or fewer Rays, as the Circumstances of Things require.

I know very well, that no Body who has never seen this will readily believe it; but in order to convince him thereof experimentally, let him be brought into the Sun-shine, or any other strong Light, or place him in a Chamber directly opposite to the Light of the Windows in a very bright Day; where, if you observe the Pupil of the Eye, you will find it to be very small in such a great Light, to the end, that the Eye may not be hurt by the strength thereof; then set him in a dark Corner of a Chamber, and turn his Face from the Light; when you will presently perceive the *Pupil* to become sensibly larger, in order to admit a greater number of Rays; insomuch, that after these Experiments, no Body can doubt of what has been here said.

Is not the great Goodness of *G O D* particularly remarkable herein, that all these Things come to pass in our Eye, without our being conscious thereof, to the end, that our Attention may not be diverted from whatever we are then contemplating? Which however would have always happen'd, if we had been obliged to have attended to every Occasion of adapting the *Pupil* to the Degrees of Light?

S E C T. XXIV. *Convictions from the foregoing Observations.*

N O W whosoever is a reasonable Person, and does plainly comprehend all that we have been saying about the Eye, ought he not to be astonish'd, that as there was a *Lucretius* among the Ancients, so there are likewise in our Age, Men that pretend to be Philosophers and Enquirers after Truth, and yet will not allow that the Maker of all these Things, which contribute towards the forming of a good Sight, had any Wise Purposes or Designs in forming the same?

And yet, if any of these Men should see a good *Microscope*, or a Set of Magnifying-Glasses, or a well-made *Telescope*, or a *dark Chamber*, with all its *Apparatus*, none of 'em will dare to say, that those Things were framed by Chance. And can they then affirm it of the Eye, the Structure of which they must own, whether they will or no, to be unspeakably finer than all the Instruments for Sight that ever were invented by the Art of Men?

Ask then the greatest Mathematician, the most skilful Man in Optics, or Mechanics, whether he can be able to make a dark Chamber, that can be turned which way one will, as readily and easily as the Eye; which, if turned towards remote Objects, can shorten itself and flatten its Glass, and upon the nearer approach of an Object, can make itself longer and its Glass rounder, without standing in need of any other Assistance; yea (let the Cause thereof be what it will) that can adapt itself to the various Distances of Objects, and accordingly form at every time a different Object; that when the Light is too small, can dilate its Hole or Opening; and when the Light is too strong, can again contract the same, without the concurrence of any Thing

Thing else besides the Disposition and Laws belonging to it?

Must he not then acknowledge that this is not in his own Power? And in case he should see such a Machine made by any Man, and compos'd only of simple fluids, which for the most part had their rise from Food, and yet sufficient to impart the Blessings of Sight to all Animals, would he not own that such an Artificer was wonderfully skilful?

What shall we then say of a Man who, finding all this done after the most glorious manner, shall still persist to deny the Wisdom of the Creator? Shall we count him Blind and Unhappy, or an obdurate Unbeliever?

SECT. XXV. *The Sun necessary to Sight: And Con-
victions from all the foregoing Observations.*

Now, to say no more, Have we no reason to acknowledge the Goodness and Power of the Great Creator, who has made such unspeakably great Bodies as the *Sun* is (not to mention the *Moon* and *Stars*) subservient to these Purposes? Who, to compleat this Design, and to make the *Eye* useful, has caused the Light to flow from thence, in so vast a Quantity, as to be able to fill the immensurable Space between us and the Firmament, even as far as to the Planet *Saturn* itself, which is supposed, and not without reason, to be enlighten'd by the *Sun*; who derives the Light itself with so unconceivable a Swiftnefs down to our Eyes, that they may be continually supplied therewith, insomuch, that if such Swiftnefs, and all the other Properties of Light, of which we have been speaking (and of which we shall treat hereafter more particularly) were not demonstrable, they might justly be doubted of by every one,

Can

Can any Body contemplate all these great Things that are necessary to make us *see*, and that co-operate as well within as without the *Eye*, and not think himself in the least obliged to Him that has bestowed such Blessings on him? Who warns him thereby timely and from afar, of so many Things, whether they be Advantageous or Prejudicial to him; who grants him the Pleasure of being able to View and Contemplate so many agreeable Colours in Fields, Trees, Flowers and the like; to sum up all in one Word, who has vouchsafed him the Faculty of SEEING; and who has made our Eye after a most astonishing manner, a perfect Stage or Theatre, from whence we may view all his Wonders, how small soever it be in Comparison of the Terrestrial and Celestial Bodies; making of his Light an admirable Pencil, for so the Mathematicians call the Composition of Rays represented in *Tab. X. Fig. 3.* by *B S T b*; as also in *Tab. XI. Fig. 2.* by *B, C C, D D, E E, b*; which proceeding from a Point as *B*, are, after due Refractions, united again in another Point *b*, by which means all his great and glorious Works of Sun, Moon, Stars, Earth, Sea, Mountains, as also Trees, Flowers, Men, Beasts, and whatever else is corporeal and visible, are painted after an inimitable manner, in their true Colours and Lineaments upon the Bottom of the Eye?

He that desires to see a Resemblance of the same, let him observe that which happens in the same manner in a *dark Chamber* by the like *Pencils* or *Rays* of *Light*.

Now did ever any Body see the Picture of a Man, or of any other Thing, well Drawn, and very Like, and which we usually term, *Drawn after the Life*, and pretend to ascribe it to an accidental Concurrence of Colours? And yet will he dare to affirm the same of the most perfect Images
of

of things that the Eye ever beheld? On the contrary, Does it not appear from the formation of the most artful and curious Theatre of the whole, great, corporeal Substance in such a little Eye-ball, that among those noble Ends which our Dread Creator propos'd to himself, this is one of the chiefest, that we should praise and honour him for the same with a thankful Heart, and in the humblest manner adore his Power and Wisdom which he has thus wonderfully impress'd on our Eyes, and thereby on our Minds? Blind and Miserable are they, yea and much to be lamented, who observing all these things, are not yet able to discover their bounden Duty therein.

It is impossible for us to quit this Subject before we be satisfy'd that a wandering Philosopher has attain'd to another Notion of himself, and of the Greatness of his Creator. If there appear'd nothing more in the Universe than what is acknowledged to be True with respect to the *Sight*, methinks nobody can remain unconvinced of the adorable Perfections of his Maker. Let an unhappy Atheist retire by himself, and seriously reflect whether he ever impartially consider'd the manner how *Vision* is perform'd, if he has not yet done it, let him begin immediately, since nothing else is necessary in this case for conviction, but an earnest scrutiny on his part; and if he finds himself still unfit, or averse thereto, let him with bended Knees implore that God whom he does not yet acknowledge, but whom others that are allowed by him to be Wise and Learned, discover so plainly in all his Works, and especially in the formation of the Eye; I say, let him address himself to that God, in hopes that he who has so wonderfully impress'd the Pictures of his Creatures on his Eye, might also impress the Knowledge of his Attributes on his Mind, and that he who enlightens his Eyes, would likewise vouchsafe to enlighten his Understanding. Can

Can it still be thought to be the result of mere Chance (since the Light, whilst it scatters and spreads its Rays asunder, is in itself improper to produce a clear and distinct Sight) that nevertheless, and only to render Men and other Living Creatures happy, Laws of *Refraction* were prescribed to this Light, by which its Rays were turned from *Divergent* into *Convergent*, that is, from scatter'd to united? Or that it is without Wisdom, that this great and unfathomable Sea of Light, in all its most minute Particles, has submitted to these Laws, without departing one Tittle from them? Of which more hereafter.

Can any Body think it to be without a wise Design, that all the Limbs of a Human Creature, from his Childhood to his Manhood, grow continually and proportionably greater, but the *Crystalline* Humour of the Eye only (so far as our Sight depends upon the Figure thereof) does, without growing and increasing, always preserve the same Size and Form both in Men and Children? See this Remark in *Bergerus*, pag. 407.

If what has been said before do not fully satisfy him of the Wisdom of his Maker, but that however he begins to be stagger'd by the Arguments that have been alledg'd, and to suspect that his Notions may be groundless, especially since he finds that the contrary Opinion is maintain'd by many whom he allows to be sagacious and free from Prejudices; let him think whether the inexpressible greatness of such a Benefit as is the *Sight*, should not stir him up to Gratitude: let him also consider that if he were depriv'd of his Sight, with what consequence such a Loss would be attended; it would be greater than we can conceive.

Particularly can any one express the Confusion in which the whole World would be involv'd, if Mankind and all other Animals were depriv'd of
their

their Sight, and were stark Blind? What could we otherwise expect than that this Globe of the Earth would be quite dispeopled in the life of one Man, and perhaps much sooner, the Air depriv'd of all its winged Creatures, the Seas and Rivers of all that swims and moves in them? Since in a very little time none would be able to search their Food for the support of their Lives, neither by themselves, nor by the help of any other. If now the Sceptick finds any manner of probability in what has been said, namely, that they who own a God, and are thankful to him for so inexpressible a Benefit, are not altogether out of the way, must not his natural Generosity, which some of these Men seem still to have retain'd, excite him to weigh it all very frequently, and with a serious assiduity to examin things over and over; to the end that if he should be mistaken in those Notions which he can never prove, and which have no other foundation but his own Fancy, he might not be guilty of a Vice so detestable to brave Souls, I mean, the highest Ingratitude towards the greatest of all Benefactors? And ought he not therefore to be perswaded of the absolute necessity he lies under, with the deepest Humility to beseech that God, of whose glorious Perfections and Works he yet so much doubts, that he would in Mercy add to all his wonderful Works, this one more, namely, farther and fully to inform him of his Duty and Dependance? For at least he will be forced to admit it for a Truth, if these great Advantages which he enjoys by his Sight and Eyes, are only bestow'd upon him that he may testify his Praise and Thankfulness to the great Giver; that the most dreadful Punishments, and greater Miseries than he ever saw to befall other Men, do justly hang over his Head, for having not only omitted those Duties, but likewise for treading under Foot, as far as he could, this Wise,
Powerful

Powerful and Gracious God. So that in case **all** the foregoing Arguments do not induce him to a Submission and Subjection to his Maker, perhaps the dread of his own Misery will make him think (since he can not deny, that if there be a Wise and Righteous God, he will certainly Punish a Disobedient and Blasphemous Creature) that this Matter is well worthy of Prayer and Inquiry, which are the only means whereby true Conviction is to be hoped for.

If any one should object that we have dwelt too long upon these Reflections, we beg them to believe that we have no other view therein, than to persuade an unhappy Philosopher, if such a one should peruse these Papers, that he would seriously consider the same; since it seems still impossible to me, that any body can comprehend it, and yet not own a God.



CONTEMPLATION XIII.

Of the Hearing.

SECT. I. *The Instruments of Hearing unknown.*

NOW if we pass from the Sense of *Seeing* to that of *Hearing*, how small Progress has the Labour of Enquirers been able yet to make, in order to penetrate into the true manner how this last is perform'd, it will only be necessary to quote the Expressions of the famous Anatomist, Monsieur *du Verney*, in the Preface of his most laudable Treatise
about

about the Instruments of Hearing: Among all the Instruments which Animals use, those of the external Senses are least of all known to us; but nevertheless, none of 'em all are attended with so much Obscurity as the Instruments of Hearing. The same is likewise acknowledged by *Valsalva*. It must not therefore be expected, that we shall set the Wisdom of the adorable Creator in this Case, either in a full Light, or even demonstrate it so plainly as has been done in the Business of Seeing; this must be the agreeable Employment of following Ages, when it shall please the great Creator to give them a Clue to this Labyrinth, and further, to bless their Enquiries, after repeated Discoveries, concerning the Instruments of Hearing, of Sound, and of Musick.

SECT. II. *But they are still sufficient to prove the Wisdom of GOD.*

HOWEVER, to shew that notwithstanding Humane Wisdom is not yet capable of finding out the right Uses of all those Instruments that belong to the Sense of Hearing; yet the Structure thereof, as far as it has hitherto been discover'd, is sufficient to prove the wonderful Wisdom of the Creator to an Enquirer after Truth; and to convince an Atheist too, if he be not more Obstinate than Ignorant: Since we have not here undertaken to describe a compleat Anatomy of these Parts, it will not be useless to transfer the following Figures from the Tables of *Valsalva*, which represent to the Life the Structure of the Instruments that serve for Hearing with respect to each other; so that from them, with some others which we shall add for greater Clearness, the Reader will be able to form a rough Conception thereof.

SECT.

S E C T. III. *The External Structure of the Ear.*

LET us then begin from the External Structure of the Ear, which every one may see in other Treatises.

Can any one suppose that it is Accidental, and without Design, that two Ears are placed upon the Head? which serve to receive Sounds by the Mediation of the Air; as may be seen in several Beasts; who, as the Sound comes from certain Places, are wont to turn the Cavity of their Ears that way; as likewise in Men; who, when one of their Ears fail them, endeavour to repair that Defect, by holding the Hollow of their Hand behind it: And can one see, without acknowledging a Design of the Creator, that when the Sonoriferous Air is come into the Cavity of the External Part of the Ear, it meets with a moveable Protuberancy at the Mouth of the Auditory Tube (called by the Anatomists the *Fragus*) by which the Air is hinder'd from avoiding this Entrance of the said Tube, and compelled to run into its Orifice or Mouth?

Now forasmuch as the Ear, if it were composed only of a soft and flabby Matter, like the Membranes, would hang down over the Orifice of the Auditory Tube, and hinder Hearing; or if it were of a harder and bony Substance, would occasion Inconveniencies in our lying down and otherwise: How manifest is the Wisdom of the Creator, who has composed the said whole Ear of Membranes supported with Cartilages? by which means it is endowed with an Elastick Faculty (as you may observe when you bend the Ear with your Hand, and let it go again) to the end that it may redress itself, and return to its former State in all Accidents; and perhaps too, as some think, to promote the Tremulous Motion of the Sonorous Air.

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This is certain, that the Auditory Tube is at the beginning of it, made of the same Cartilaginous Substance with the Ear, but farther in it, consists of Bone only, as is sufficiently known to the Anatomists.

SECT. IV. *The Auditory Tube, and the Membrane called the Tympanum or Drum.*

To say something more of this, let (*Tab. XL Fig. 3.*) *LL* be the Circumference of the extreme Part of the Ear, and *K* the circular Cavity that appears therein (called the *Concha* or Shell) and which can be seen outwardly; and in which is also the Orifice of a Tube *AC*, which, extending it self internally in the Head, is called the *Auditory Tube*.

This consisting of a Cartilage about that Part of the Ear mark'd *A*, and afterwards as far as *C*, of a Bone only, is cloathed on the inside with a Skin or Membrane, which in this Figure is represented alone without the Bone and Cartilage; and at the End of it *F*, it is shut up by a Membrane which is round, dry, thin, solid and transparent, and which is called the *Drum* of the *Ear*. But some are of Opinion, that there is a small Orifice in this Membrane, which seems to be in some measure likely, because such as take Tobacco have been observed to convey the Smoak thereof from the Mouth thro' the Ears.

And thus we see how the Sonoriferous Air, admitted into that Part of the Ear *LL*, and collected in the *Concha K*, enters into the Auditory Tube, and passing from *A* to *C*, strikes against the Membrane *F*, and puts it into Motion.

SECT. V. *The Cavity called the Drum, the Bones of the Ear, and the Chorda or Little String.*

BEHIND the Membrane of the Drum, more inwardly in the Head, there is a certain Cavity, which the Anatomists call the *Tympanum* or Drum, upon which you must suppose that this Membrane is extended much after the same manner as the Skin of a Kettle-Drum.

In this Cavity Anatomists observe several wonderful Things, some of which are contained within it, and others in its Circumference: The first things within it, are the four little Bones of the Ear, and a small Nerve, called the *Chorda Tympani*, or String of the Drum; to say nothing here of the Muscles, and other Singularities that occur therein. The other things consist mostly in the Openings that appear in the Bone of the Drum's Circumference, whereby the Cavity thereof has a Communication with other Cavities, either with, or without the intervention of Membranes.

The Auditory Bones (*Tab. XI. Fig. 4.*) are found to be four in number, *CS* is the *Hammer*, *BP* the *Anvil*, *PV* the *Stirrup*; and between the Anvil and Stirrup there lies at *P*, a small roundish Bone, which makes the fourth in Number.

Between two of these Bones (*Tab. IX. Fig. 3.*) there is a little Branch of a Nerve *EO*, or *String* of the *Drum*.

SECT. VI. *The Motion of those Instruments.*

NOW if we suppose that the Tail *S*, of the Hammer *CS*, is fasten'd to the Membrane of the Drum which lies there under it, we may observe at the same time, that this Membrane being moved by the Sound, which passing into the Auditory Tube

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AC, strikes upon it, will likewise move the Hammer *CS*, as that will do the Anvil *BP*; by which last, and by the fourth little Bone *P* (*Tab. XI. Fig. 4.*) the Stirrup *VP*, will likewise be moved: And so the little String or Nerve *EO* (*Tab. XI. Fig. 3.* when the Hammer *CS*, and the Anvil *BP*, are stirred by the Membrane of the Drum,) will always follow the Motions thereof: So that from hence it appears, that the Motion of the Membrane of the Drum, communicates itself to all these little Bones, and to the *Chorda Tympani*.

SECT. VII. *The Openings in the Circumference of the Cavity of the Drum.*

TO have a true Notion of the Circumference of this Cavity, which an unskilful Person must take care to distinguish from the Membrane of the Drum, since *Valsalva* has not drawn it entirely, but only the Openings that are therein; you must suppose it to be a Cavity that comes behind the Membrane of the Drum (*Tab. XI. Fig. 3.*) and encompasses these little Bones: Or you may consult hereupon the Figures thereof in Monsieur *du Verney*, which, if we should here reckon them up, would require too many Explanations.

In this Circumference then of the Cavity of the Drum Anatomists do find;

1. The Opening of the inmost part of the Auditory Tube *AC* (*Tab. XI. Fig. 3.*) which is shut up by the Drum Membrane *F*.

2. The opening *H*, of the Tube *HGI*, called the Trumpet of *Eustachius*, which terminates at *I*, in the furthestmost Part of the Roof of the Mouth; so that the Air passing thro' it from the Mouth; from *I* to *H*, can enter into the Cavity of the Drum, and be again discharged the same way. The Wisdom of the Creator does wonderfully appear, in

making this Orifice in the Roof of the Mouth after such a manner, that the fresh Air drawn in by the Nostrils, is directed in its way thither by a little Protuberancy ; and when it returns from the Lungs, charged with Vapours, it passes by this Orifice more easily than it can enter into it.

Valsalva shews by Experience, that, this being stopt, the Ear on the same side is immediately Deaf ; but when open'd, hears again.

And this, according to all Appearances, is that Passage for Sounds, by the help of which, Men that have been entirely Deaf, have sometimes been able to tune a Musical Instrument, and others have been found to hear by the Mouth ; for which purpose, a little Stick, held between the Teeth, or set against it with one End, has oftentimes done great Service, whilst the other End, resting upon the Instrument, serves for a Passage to the Tremulous Motion of the Air. The Passage of the Tobacco Smoak from the Mouth to the Ear, of which we have already spoken, may perhaps be traced after the same manner.

3. The little Part of the Bone *D*, is the side of a Bay or Creek, which makes the Cavity of the Drum larger, and is continued to the Cavity of another Bone, called the *Apophysis Mammillaris*, or *Mastoides*. In the first Entrance of this Bay, the sharp End of the Anvil rests, as may be seen at *D*.

4. In the upper Part of this Bay, *Valsalva* has discover'd several Holes, by which there is a Communication between the Cavity of the Drum and that of the Skull itself.

5. There are yet two Openings in the Circumference of the Drum ; the first of 'em are called the *Oval Window* (*Tab. XI. Fig. 5*) *o*, and this Opening is stopt by the *Stirrup*.

6. The other is called the *Round Window* *p* ; which is shut by a Membrane like that of the Drum. You must

must suppose, that both these Openings, *o* and *p*, are here in one Bone, which is a part of the Circumference of the Drum's Cavity; and that all these Threads and little Tubes 1, 2, 3, 4, are quite out of the Drum's Cavity, which we have put out of the way, that they mayn't hinder the Sight of them.

SECT. VIII. *The Labyrinth or Maze of the Ear.*

THESE two Oval and Round Windows open the way for Enquirers to the last and most inward Cavity of the Ear, which, by reason of its wonderful Figure, is call'd the *Labyrinth*. Being strip'd of the Bones that lie about it, it shews itself as described in the Table, only the End or Point of this Snail's Course 4, must be shewn somewhat rising from the Paper, and not lying in the same plane with all its Windings, just as you see in the Snails themselves, their Point a little elevated. I add this Remark, because mention'd by *Valsalva*. You may see it better delineated in *Tab. XII. Fig. 1.* but with the same Fault as *Tab. XI. Fig. 6.* and the better to shew all the Parts, the Labyrinths are placed in a different Situation.

The Parts of this last Cavity (the Labyrinth) are commonly divided into three; namely, First, three Semi-circular Vessels, 1, 2, 3. Secondly, the *Cochlea* or Snail 4; and Thirdly, a Cavity call'd the *Vestibulum* or Porch, which lies between the two, and which, for the greater clearness, is represented open, (*Tab. XI. Fig. 6.*) To say a Word or two of each.

We see that these Semi-circular Vessels, 1, 2, 3, have an Opening at each End into the *Vestibulum*; but that two of 'em 1 and 2, are united in one Vessel at 5 and 6: And therefore, that there are not six but five Orifices in the whole: Moreover,

we see on the side opposite to the Porch the *Cochlea* 4, this is divided according to its Length and Bending into two particular Tubes by a kind of a *Septum* or Partition-Membrane; which likewise, according to its Length, consists of two different Sorts of Matters; the one is membranous, which *Valsalva* (see his *Tab. VIII. Fig. 7.*) thinks is probably formed from a Branch *e*, of the Soft Auditory Nerve spread out into a Membrane (*Tab. XI. Fig. 7.*) And the other kind of Matter is dry, thin and rough, according to *Du Verney*, and between the solidity of a Cartilage and a Membrane, as *Valsalva* says of it. This at least seems to be true, that this Matter renders the *Septum* very fit for propagating the Tremulous Motion of the Sound.

Of the two Tubes which are made in the *Cochlea* 4, one is shut up in a Membrane; and the round Window *p*, of which mention is made above (*Tab. XI. Fig. 5.*) in the Opening itself: So that between this Tube, or rather between the half Cavity of the *Cochlea* and the Drum's Cavity, nothing but this Membrane does appear.

Tab. XI. Fig. 6. r is likewise the Orifice of another Tube, which is open at the *Vestibulum*.

The Anatomists name both these Tubes, into which the Cavity of the *Cochlea* 4 is divided, the *Scala* or Stairs.

Lastly, we find that the *Vestibulum* (besides the five Openings of the Semi-circular Vessels, one of the *Cochlea*, and still five others thro' which the Auditory Nerves pass, and by which these Openings are stoppt) has yet one more represented (*Tab. XI. Fig. 5.*) by *o*, and *Fig. 6.* by *q*; viz. the afore-mentioned Oval Window, which is stoppt by the little Bone of the Ear called the Stirrup; yet in such a manner, that the Membrane which is between that Bone and the Edge of this oval Opening or Window, gives a Liberty to the Stirrup to be moved upwards and downwards.

S E C T.

SECT. IX. *The Auditory Nerves.*

BEFORE we go any farther, we must say something of the Auditory Nerves, the Soft Parts whereof *cd* (*Tab. XI. Fig. 7.*) being divided into five Branches, pass thro' the aforesaid Openings into the *Vestibulum*, where, being expanded, they compose the Membrane of this *Vestibulum*; and from this Membrane likewise, there proceed five others, which entering into the Semi-circular Vessels, and coming with each other from both sides, are united in one Membrane. You may see them in this Figure, which appears sufficiently in *Fig. 6.* if instead of the Tubes you suppose you see the Membranes which are there, and which are made of the expanded Auditory Nerves.

So likewise, according to *Valsalva*, the little Branch of the Nerve *e* in the *Cochlea*, produces the Membrane *g*, which, as we said before, makes one side of the *Septum*, that divides the whole *Cochlea* into two Tubes.

SECT. X. *All the Instruments of Hearing shewn.*

AFTER all these Particulars, we shall proceed to represent the entire Structure of the Instruments of Hearing jointly with one another, and at the same time, give you a brief Account of the Opinions of the Principal Anatomists concerning their respective Uses: You may see them in *Tab. XII. Fig. 1.* which, to range them in order as they appear, did not cost a little trouble to *Valsalva*, as he himself says of it.

Here then we find the Ear represented, not as it is seen before, or as it is extended towards the Face; but inflected a little towards the hinder Part of the Head, to shew all the other Matters more plainly.

A A is the Ear, in which the Sound is inclosed ; and *B* the *Cocblea*, or Shell, in which the Sonorous Air is collected, which, passing from thence into the Auditory Tube *C C*, strikes upon the Membrane of the Drum *e g o*, and thereby communicates a Tremulous Motion to the said Membrane.

SECT. XI. *An Experiment shewing that the Auditory Tube increases the Sound.*

IT must not be thought that this is said without any ground, since it is very probable, that the Air, passing thro' the *Cocblea B*, and the Auditory Tube *C C* (which together make a natural Speaking-Horn or Trumpet) strikes much more strongly upon the Drum-Membrane that shuts the said Tube, than if it struck against the said Membrane, without passing thro' this Tube.

This is plain in such as are Deaf, and who are obliged sometimes to put into their Ear, either a crooked or strait Tube, the Mouth of which is large, and the lower part narrower, in order to hear the better.

And if a Man that is not deaf has a mind to make the Tryal, let him take one of those speaking Trumpets that were invented in the last Century (see *Tab. XII. Fig. 2.*) *A E*, and set the narrow Part of it against his Ear, and let some Body whisper softly at the wide Part *E*; and he shall find, tho' the Tube be about Six Foot long, as mine is, that he will hear the Speaker very plainly and distinctly, even at the time when other Persons, standing much nearer to the Mouth of him that speaks, and list'ning with all the Attention they can, will not be able, by reason of the lowness of his Voice, to hear or understand any Thing he says,

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After the same manner we likewise perceive, that the Sound produced by blowing thro' a Trumpet or Horn, is heard incomparably louder than that which any Man can make with his Mouth only.

SECT. XII. *Sounds produce a Tremulous Motion in the Drum-Membrane, shewn Experimentally.*

NOW to shew farther, that the Air acting more strongly upon the Drum-Membrane *c g o*, thro' this natural Auditory Tube *A A B C C* (*Tab. XII. Fig. 1.*) produces therein a shivering or tremulous Motion, one might first instance in the manner that all resounding Bodies are moved, which, vibrating swiftly backwards and forwards, strike against the *Circumambient* Particles of Air, and so communicate this tremulous Motion. One may perceive this same tremulous Motion very sensibly in Bells, in the Strings of Musical Instruments and other Things, by laying one's Finger or any other Matter upon them when they are made to sound; and very plainly in the known Experiment of a Drinking-Glass with a little Water in it, by wetting the Finger and pressing it round the Brim; and at the same time that it yields a Sound, if you place the other Hand at the Foot or Bottom of the Glass, you may feel the said tremulous Motion.

And to see, by way of Comparison, how the Air is moved by such a resounding Glass, you need only pour as much more Water in it, which will fill it almost to the Brim, when pressing the said Brim round again with the Finger, you will visibly discover in the Water, the tremulous Motion occasion'd by the Glass; just so is the Air likewise moved.

S E C T. XIII. *Other Experiments proving the same Thing.*

BUT not to discourse too long nor too deeply about the Nature of Sounds, which are not yet fully known to us, this is sufficiently certain, that after what manner soever the Air be put into Motion, in order to produce Sounds, it is capable of causing the Bodies against which it strikes to tremble.

Now, to say nothing here of those Motions which the Sound of a Cannon produces in the Air, and by which it causes Doors and Glasses, with many other solid Bodies, not only to tremble, but to burst in pieces; this is very plain, that if you strike with your Finger upon the Thread or String of a Musical Instrument, for instance, a Violin; the other Hand, in which you hold the said Instrument, will in some measure feel the Wood to tremble.

But now to shew the Analogy thereof with the Ear, about which we have been treating; take away the Mouth-Piece of a Speaking-Trumpet, *A, B, C* (*Tab. XII. Fig. 2.*) and instead thereof, let a dry thin Hog's Bladder be spread over the Orifice as smooth and tight as may be; or in case the Rim or Edge of the said Trumpet *B C*, be armed with a kind of Teeth, as some are for Ornament-sake, and that there be danger from thence of bursting the Bladder in the Expansion thereof, you may put a four-double Paper, with a great round Hole in the middle, upon those Teeth, before you spread the Bladder over them; this being done, let the Trumpet, with its largest Orifice *D F*, be placed upon the side of two Chairs, so that it may stand streight up, and the Bladder be on the Top at *B C*.

Now

Now in case you should lay three or four little Feathers of a Quill upon the said Bladder, and cause a Man lying upon his Back upon the Floor, with his Head between the two Chairs, and his Mouth directly under the middle of the Tube *E*, to call or speak out aloud, you shall perceive, that the Sound striking upon the Bladder, will produce a tremulous Motion in the same, and in the little Feathers lying upon it; which Motion, or Trembling, may be likewise felt, if you hold the Tube in your Hand, and lay your Finger upon the Bladder at *BC*, when any Body speaks whose Mouth is placed at *E*.

Thus then we see (taking the Speaking-Trumpet for the Auditory Tube *AABC* (*Tab. XII. Fig. 1.*) and the Bladder for the Drum-Membrane, which is expanded over the Auditory Tube at *cgoO*; that the said Membrane must be affected with a tremulous Motion, by the Sound entering the Ear, as also the Hammer *n*, whose Stalk or Handle is fasten'd to the Drum-Membrane.

SECT. XIV. *The Tremulous Motion of the Auditory Bones.*

Now by this Hammer must the little Nerve *c7* (which shews itself here between the Hammer *n* and the Anvil *m*) be likewise moved; of which we shall say something more hereafter. But it is particularly plain that the Hammer *n*, being moved by the tremulous Motion of the Drum-Membrane, derives the same Motion to the Anvil *m*, and by that to the Stirrup *p*.

The Stirrup *p*, which does here close the Oval Orifice in the Porch *4*, both by itself and the Membrane that surrounds it (this Orifice does not appear very plain here, but you may see it in (*Tab. XI. Fig. 5.* at *o*, and *Fig. 6.* at *q*) being thus put into a tremulous Motion, both by the Sound and by
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the trembling of the Drum-Membrane, and the rest of the Auditory Bones; we likewise see that the Air in the Porch 4, and moreover in the Semicircular Vessels 1, 2, 3, and in the one Tube, or half of the *Cochlea* 5, will be moved; and also through the round Orifice *p*, (*Tab. XI. Fig. 5.*) the Air in the other Tube, and like the former (*Tab. XII. Fig. 1.*) by the Auditory Bones, or by the Hammer *a*, the Anvil *m*, and the Stirrup *p*; but by the motion of the Air in the Cavity of the Drum, which is to be found between the Drum-Membrane and this round Orifice; which Air being moved by the Drum-Membrane, and likewise by that Membrane that closes the round Orifice *p* (*Tab. XI. Fig. 5.*) and the Air *Tab. XII. Fig. 1.*) that is behind in the other half Tube of the *Cochlea* 5, will be moved. This is the Opinion of Monsieur *du Verney*, about the round Window, from whom *Valsalva* does herein somewhat differ: They that please may consult 'em both, or stay till the uncertainty of the Use of this round Orifice be removed by future Experiments. But to proceed:

SECT. XV. *The like Motion in the Membrane of the Labyrinth.*

THIS Air being put now into Motion throughout the whole Labyrinth 1, 2, 3, 4, 5, (*Tab. XII. Fig. 1.*) the Membranes (that are therein, and are represented by *Fig. 7. Tab. XI.*) or rather the Auditory Nerve 6, must needs be moved thereby; which Nerve enters this Labyrinth thro' five Orifices (*Tab. XII. Fig. 1.*) three of which are seen on this side the Porch like so many Points; and being there, and spreading out its Branches into Membranes (when they are moved by the Air) as well in the Porch as in the three Semi-circular Vessels, and the *Cochlea*, the Sense of Hearing is thereby produced.

So

So that finally these Nervous Membranes in all the Cavities and Tubes of the Labyrinth 1, 2, 3, 4, 5, seem to be the Instruments by which, and the Labyrinth itself the Place where, the Hearing is formed, because the motion of the Sound does there affect the Auditory Nerves, or the Membranes produced by the Expansion of the same.

Now that this is not advanced by many, without good Grounds, seems to be in some manner proved by an Observation which *Valsalva* made upon the Body of a Deaf Person. *Cb. II. §. 10.* where the Membrane that encompasses the Stirrup, and shuts the Oval Orifice, was found to be all Bone, and for that reason the Stirrup was immoveable, which, according to him, was the Cause of that Deafness; to which we may add, that the Drum-Membrane being broken, the Hearing does not immediately fail, but only after a good while, when the other Instruments of Hearing, lying too naked and exposed to the Air, are perhaps corrupted. So that properly the Drum-Membrane does not seem to be the immediate Instrument of Hearing.

SECT. XVI. *Convictions from some Particulars.*

I now leave it to the Judgment of an Atheist himself, how many things relating to the Uses of these Instruments of Hearing may be still concealed from us; or, whether so many as are hitherto known to us, are formed and fixed in the Place where we find them by mere Chance, or without a wise Design?

Dares he now ascribe the Figure of those little Trumpets or Horns that Deaf People make use of, to Chance, or ignorant Causes? Can he then with the least Appearance of Reason, advance such Notions of this which is found in the Ears of all
Men

Men *L L*, and is represented in *Tab. XI. Fig. 3.* by the *Concha K*, and the Auditory Tube *A B C*.

Especially knowing, as he does, the Inconveniences which any little Things or Insects produce, when they get into that Tube; and seeing besides, that that Vessel is encompassed with a number of small Glands at *A*, which have likewise their own little Vessels, from whence a tough and yellow Matter is continually filtrated; the Use whereof is not only to preserve the Tube in a proper State of moisture, so that it may not be too much dry'd by the Air, nor yet render'd too soft and flabby, if the said Matter were thinner; but chiefly to stop the way to the innermost Part of the Ear, and Barricade it against Flies and other little Animals by the aforesaid tough Matter, and also by the little Hairs that grow therein; and in case any of those Creatures should have insinuated themselves too far, the bitterish Taste of that Matter will deterr them from advancing any further.

The Wonders of this Structure of the Ear, so far as they relate to the little Muscles placed therein, may be seen in the Books of those who have learnedly treated of the same, such as *Valsalva*, *Du Verney* and others: *d* is one of those Muscles represented in *Tab. XII. Fig. 1.* as separated from the Bone-Tube in which it is placed; which also serves to draw the Hammer, and thereby more or less to expand the Drum-Membrane, and, together with the other Muscle *ff*, to open at the proper time the Tube *H I*, which runs from the Cavity of the Drum, to the hindmost Part of the Roof: At *g* we see a small Muscle, which is inserted in the Head of the Stirrup, and which can stretch more or less the little Membrane that shuts the Oval Orifice, in order to render it more Serviceable to the motion of the Sound. But this we shall pass by.

SECT. XVII. *The Difference between the Instruments of Hearing in Young and Grown People.*

NOW if the Wisdom of the Creator does not palpably appear from all the foregoing, let any reasonable Body judge, when he sees, that in *Tab. XII. Fig. 1.* the little bones of Hearing *n, m, p,* and those that compose the Labyrinth *1, 2, 3, 4, 5,* are of the very same Size in a little Child as in a grown Man; whereas all other Bones do mostly grow with the Body; the reason of which, as it should seem, is, that in case the Instruments of Hearing should alter, the Voice of the Children themselves, of their Parents, and other Sounds, already known to Children, might, by the growth of these Instruments, become strange and uncouth to them, and so occasion Mistakes and Confusion.

And to be convinced, that this happens with Design, and merely by the Wisdom of the Creator, we need only take notice, that where it is necessary that all these things should remain in the same State in a Child and in a grown Person, the same does accordingly happen; but when any Alteration is necessary, that also happens: Accordingly in a grown Person it is necessary that the Auditory Tube *B.C.C,* should be wholly open to the Drum-Membrane *c, g, o, c,* and the Membrane of the Drum itself dry, and not too flabby; But if this should happen in the same manner in Children, that Moisture, with which they are encompassed before their Birth, would render the Drum-Membrane too soft and flabby to be of use to them afterwards: From whence it is, as Anatomists observe, that the Auditory Tube in new-born Children, is narrower, and stoppt by another kind of Matter, insomuch, that the Humidity of the Matrix cannot approach it; which stopping Matter is found to disappear of itself

itself in a few Days after the Birth, to accustom the Children by degrees to the Impression of the Air upon the Drum-Membrane, and so to the Sense of Hearing, of which they are deprived even after Birth, so long as this Obstruction lasts in the Auditory Tube.

SECT. XVIII. *Convictions from what has been said.*

Now let an unhappy Atheist ask himself whether this can be ascrib'd to Necessary and Ignorant Causes (as for *Chance*, I believe no body will pretend it) that whereas the Sense of *Hearing* requires proper Instruments both in Young and Old, the said Instruments are of the same Magnitude and Form in both ; and that wherever it was necessary that there should be a Difference, we find not only such a Difference, but even such a one as is best adapted to the respective Ages of grown Men, and of Children ?

Yea to one that has not lost the use of his Reason, this alone seems to evince the Goodness and Wisdom of our Creator, insomuch that to discover the adorable Traces and Footsteps of a Divine Being, the most obstinate Atheist need only seriously to contemplate the first *Figure* in *Tab. XII.* and consider at the same time, that this is the wonderful Structure, which like the Work of a Statuary, is as it were hew'd out of the hardest Bone in all Men, and bestows on all Creatures the Happiness of *Hearing*.

The only Evasion therefore to which such a miserable Philosopher can betake himself, is : that the Uses whereto all these Parts are peculiarly adapted, be not yet entirely manifested to Inquirers ; which makes them still hope that a dreadful God, whom they have so frequently Blasphem'd, is not to be discover'd in the Texture of the Auditory Tubes.

Tubes and Instruments: as if every Thing that is not perfectly understood by them, must be immediately imputed to Fortuitous Productions.

In answer to which we beg him to consider with himself, whether all rational Persons will not condemn this Method of drawing such an Absurd Conclusion from his own Ignorance only; and tell him that, far from making his own weak Conceptions the ground of his Inference, that those Things are form'd without Wisdom; the great Advantages resulting from the Thing itself, must needs induce him to conclude thereupon, that the Maker of it was not only Wise, but in a much higher degree more Wise than he who passes this Judgment on such a wonderful Machine; and that it would be much more commendable in him earnestly to endeavour to understand it all, and to examin into this Wisdom, which, tho' yet conceal'd from him, ought nevertheless to be the Object of his Adoration.

Can he show us plainly and clearly how *Sounds* are produced in *Trumpets*, *Haut-bois*, and other Wind-Musick? Can he account for the Motions and Modulations of the Air inclos'd in them? Are not innumerable Circumstances relating to the Instruments of *Sound*, to the variations of *Tones*, and what else belongs to the same, still a Secret to him, and the greatest Philosophers? And yet would he presume to ascribe their Structure, when he observes their Uses, to Chance or Ignorant Causes, and conclude that it was to these they ow'd their Original?

When therefore he contemplates the Instruments of *Hearing* so necessary to all Men living, and the great number of them, let him, in order to come to a sounder Mind, ask himself, whether if he could with any shew of Reason suppose a Man, from whom he had nothing to fear, to be the Inventer thereof, he could not, with much less Scruple of

Conscience, impute the Wisdom of such an Invention, to such a Man, than to Fortuitous and Ignorant Causes : and therefore whether it be not the Fear of being forced to own an Adorable and Powerful Creator which restrains him, rather than the true Evidence of his own Mind ; how much sooner he pretends, that nothing else induces him to deny all the Wisdom and Contrivance in these Things.

I say once again, let our unhappy Philosopher inquire strictly into these Things, forasmuch as not only his Eternal Happiness (which perhaps is a Jest to him) but all his Content Pleasure and Ease even in this Life do entirely depend upon it ; for the Matter being so, that it is rather out of fear of meeting a great, and, to his Enemies, a Terrible God herein, than from the Conviction of his Judgment, that he refuses to acknowledge his Dread Creator, and yet continues to Blaspheme him and his glorious Attributes, how can he at all be released from such Fear ? How can he ever attain any certain Tranquility in this Life ? When from the Thousands of Objects, even from every Thing that he Hears, Sees, Smells, Tasts and Feels, he is continually put to seek for Arguments to quiet his Mind against the Wisdom, Power and Goodness of the great Creator, which shine forth so clearly in all of them : and in each of which, if he does but discover any Thing of those Attributes, as obscure and dark as they may appear to him, he will find new, and perpetual Occasions of Terror. And since he can no other way defend his Notions, but by pretending that he is still dissatisfy'd in a Business, of which so many wise Men own themselves fully convinced, and of the Happiness resulting from such Conviction, will he not feel (in contemplating the smallest Creature in this his uncertainty, whether those who own and serve a God are

are in the right) that continual Doubtings in spite of all his endeavours will arise in his Mind, and threaten him, in case his Notions are wrong, with utter Ruin from the Displeasure of his Maker?

Let an Atheist think with himself whether all this be not true, and how Deplorable then his Condition must be. And whether our Creator himself does not justly make use of the *Ear* to convince such as he in the 94 *Psalms*, v. 8, and 9. *Understand ye Brutish among the People; and ye Fools when will ye be Wise? He that Planted the Ear, shall he not Hear? He that formed the Eye, shall he not see?* I beg him therefore to reflect in good earnest upon these Things.

SECT. XIX. *What is meant by Sound.*

NOW whether or no the Spirit of God has thought fit to hint at the chief Properties of *Hearing*, since Natural Philosophy has not yet clear'd up the same: this is plain that the Properties which are best known to us at this time, seem to be discoverable in his Holy Word.

To give a few Instances thereof: It is obvious that all we *Hear* is only a kind of *Sound*; this has been consider'd as a Quality inherent in the Body, by all the Antient Inquirers into Nature, but a more strict and distinct Scrutiny has convinced later Ages, that by *Sound* a twofold Thing is commonly understood.

First, A Motion in the Bodies from whence *Sound* arises, which again produces a tremulous Motion in the Air, as that again moves the Instruments of *Hearing*, by the *Tympanum*, against which it first strikes. And this Kind, which consists only in such a Motion, is called by the Learned, *Sonus Primus*. Vid. *Bobnius* and *Bergerus* in their Treatises about *Sounds*.

Secondly, By the Word *Sound* is likewise meant, that Sensation produced in us by such a Motion; so that we must not imagin that what we Hear is in the Bodies or Air that surround us, in which we perceive nothing but a certain Sort of Motion; just as in the Sensations produced in our Body by the Prick of a Pin, concerning which we must not fancy that the Pain we feel is without us, either in the Pin itself, or in other Bodies: but that what we name the sensible or Audible *Sound*, does indeed begin in our *Ears* by such Motion of the Air, but does not acquire the true Properties of *Sound* till it be perceiv'd by the Soul, which is after an unconceivable manner united to the Body. And is what we call *Sonus Secundus*.

So that, not to concern ourselves here, how the Soul is affected, there is one *Sound* which is form'd, and has its existence in external Bodies; and another *Sound* in the Ear, and particularly in the *Labyrinth*, by the Membranes that compose the extended Auditory Nerve; but properly in the Soul, by the Passions and Sensations which are excited therein.

Now if any one should insist, as it is the Hypothesis of some Philosophers, that all this belongs to one and the same *Sound*, it is but only changing the Names, and there will be no Harm in it; it is no less true however, that, notwithstanding all these Things must concur to produce a Sound perfect in all its Circumstances, the Name of *Sound* is given by the Modern Philosophers to both; by which means many Properties thereof are describ'd with ease and brevity.

SECT. XX. *The Instruments of Hearing are unnecessary without Air. And Convictions from thence.*

NOW, as the Eye without Light, so this wonderful Structure of the Instruments of Hearing, would be in a manner useless, if he, that takes such great Care of all his Creatures, had not vouchsafed to encompass that Globe upon which they live with a vast Ocean of Air. Does not this then administer an occasion to us also, to praise the Goodness and Wisdom of the Creator, who has been pleased so to adjust these Instruments of Hearing, that whilst Men live and breath in the Air, they are exactly adapted to discover to us, after such a wonderful Manner, the Motion thereof, by means of an Impression which the Sound produces in us; and which is only applicable to this Sense of Hearing?

Will any one dare to maintain, if he saw a Ship sailing with all its Tackle, that the Ropes, Sails, Pullies, and whatsoever else is necessary to adapt it to the Wind, are put into such a State by mere Chance, or without Design; and yet that every one of them was very useful in causing the Ship to move? And is it not more unreasonable to assert the same of these wonderful Things, which, as to the manner of their Operation, have hitherto been inscrutable? For these are not governed by a strong and sensible Motion of the Air, such as the Wind is, but are adapted by a much more secret and insensible Motion thereof, with the Assistance of several Muscles, which dilate or contract these Instruments of Hearing: And yet it must be confess'd, that the Uses and Advantages of such a Motion are much greater than that produced by the Wind in a Ship, in which latter a very few may be concerned, but the former affects all living Creatures; and

the Benefit thereof is communicated to them after the most convenient manner, and even without any Concurrence or Trouble on their Part.

S E C T. XXI. *The Nerves that are moved in Hearing.*

To proceed now to those other Matters of which we promised to say something in the following Discourse: We have shewn before, in *Tab. XI. Fig. 3.* a small Nervous Body *E O* (which in *Tab. XII. Fig. 1.* is represented by *c 7*) This is observed to run across the Drum-Membrane, between the two Auditory Bones, *viz.* the Hammer *C S*, and the Anvil *B P*; and forasmuch as the Hammer *C S* is fasten'd to the said Drum-Membrane, tis plain enough, that that Membrane being moved by Sounds, such Motion must necessarily be continued to the Hammer, and to the said Nervous Cord or String *E O*: So that in every Motion of the Drum-Membrane, that is, as often as one hears any thing, this little Nerve *E O*, is put into a tremulous Motion:

S E C T. XXII. *The Use of the said Nervous Cord.*

CONCERNING the right Use of this little Nerve the Opinions of the Anatomists are various, all of 'em looking upon it as a thing sufficiently obscure. It is called by the Antients *Chorda Tympani*, or the String of the Drum, and esteemed to be of the same Use as the Strings of the Soldiers Drums.

Mr. *Maurice Hoffman* in his *Idea Machinæ*, p. 232. has collected the several Notions of the Learned about this Nervous String. *Fallopins*, says he, was uncertain what it was; *Eustachius* takes it for a Branch of the Nerves of the Fourth Pair; notwithstanding

ing which *Mr. Gasper Hoffman* acknowledges ingeniously, that he did not know what sort of a Body this was, nor to what End, nor where it was inserted; and thought it might be an uncertain Work of sporting Nature, and that a great many were mistaken concerning it. Whereupon *Riolanus* having since answer'd him, says, that it is a nervous Fibre derived from the Auditory Nerve. Finally, *Monsieur du Verney* has irrefragably proved, that this nervous Cord is a Branch of the Fifth Pair, which proceeding forwards, joins itself to the hard Auditory Nerve.

The said *Monsieur Du Verney* lays down the Use thereof in his Treatise *de Organ. Audit.* p. 12, 13. saying, that it communicates Branches to the little Muscles of the Auditory Bones, and what else there may be in the Cavity of the Drum, in order to produce Motion.

Monsieur M. Hoffman supposes, that it serves to communicate Motion and Sensation to the Drum-Membrane, at least to give it its proper Tension.

Touching this String, the Reader may consult *Valsalva*, who having written later than the above-mention'd Gentleman, has declared his Opinion with some Warmth in his *Accurate Description of the Ear*, Cap. II. §. 22. These are his Words as they stand there; *Moreover that this nervous Branch runs so naked and undiscover'd, so simple and alone, so regularly and so constantly thro' the Cavity of the Drum, and particularly that it lyes so between the Auditory Bones, that it is immediately put into Motion as soon as ever the said Bones are moved; all these Things shew, that there is some great Mystery of Nature concealed in this Branch, and have therefore induced me frequently to contemplate the same both with my Eyes and my Mind, being desirous to find out something perhaps new in the Dissection, or at least the Causes thereof.* After which he tells us what his Thoughts were concerning it, and what he had be-

gun to discover therein, and so concludes with these Words: *But since I have not yet had an Opportunity to employ so much Pains as I was desirous, and as was requisite in this Matter, I shall content myself with having made known my Intentions and Purposes, and say no more about it at present.*

This Gentleman does likewise own, that this Branch lyes between the Fifth Pair and the Auditory Nerve; but adds, that he can't see, why we may not as well take it for a Branch of the Auditory Nerve, carried on to the Fifth Pair, as a Branch derived from the Fifth Pair to the said Auditory Nerve: But whether we maintain it to be the first or the last with Monsieur *Du Verney*, it is certain, that this String has likewise a Communication with the Fifth Pair; and that being put into Motion by Sounds, it cannot avoid continuing such Motion, both to the Fifth Pair and to the Auditory Nerves.

I have been more prolix in relating the Sentiments of the Principal Anatomists upon this Matter, to shew that this little *nervous Cord* has occasion'd very serious Reflections among several Persons, and that many have suspected, that there is something strange and uncommon therein: And I should not have offer'd my own Opinions concerning the Operations of the said Cord, and the Purposes for which it seems to be made, were it not to convince the Atheists and Unbelievers, or at least Weak and Wavering Christians, that they will find something in the Structure and Contrivance of this String, that may excite in them not only Admiration, but also Reverence for the adorable Maker of it. To propose it therefore briefly:

SECT. XXIII. *The Fifth Pair of Nerves to excite the Passions.*

How much the Fifth Pair of Nerves contributes towards exciting our Passions or Inclinations; with respect to the *Intercostal Nerves*, which issuing frequently with a double Branch out of the said Fifth Pair, liberally communicate Springs to all the Parts of our Body, and cause Motions therein, may be learned from the Words of this great Enquirer into the Nerves, *Viscussens*, p. 236 in 8vo. who says, That the said Pair is not only carried on to the Eyes, Nose, Palate, Tongue, Teeth, and all the Parts of the Mouth and Face; but that it likewise derives its Branches to every thing that is in the Breast and Belly, and is even continued down to the Feet by the *Intercostals*; Adding farther, p. 327. that this Communication of the Branches of the Fifth Pair is, among other things likewise, the Cause why, pursuant to the various Motions that are produced in the Brain, all the Parts of the Body, and particularly of the Breast, are differently affected, and the Signs of our Inclinations impressed upon our Faces, which are altogether adapted to those Passions that are moved; and accordingly by the Changes of our Countenances, the several *Emotions*, or Affections of Love and Hatred, of Joy and Sorrow, of Fear and Boldness, are clearly expressed.

SECT. XXIV. *The Dura-Mater produces the like Emotions.*

Secondly, How much the Motions of the *Dura-Mater*, which encompasses the Nerves, do likewise contribute to the producing these Passions and Emotions in the Mind, is known to Surgeons when they touch the same, and to Physicians too very fre-

frequently in the Distemper called the *Phrenitis* or Frensey, in which it appears that by the pricking of this Membrane (whereby its Expansion is augmented, and the manner of Motion alter'd (confused Thoughts and extravagant Passions; sometimes Weeping, then again a sudden fit of Laughter; one while Fear, another while Boldness and Anger, and innumerable other irregular Motions in Actions and Words, without any external apparent Cause, are produced in the poor Patient. Now this great Instrument of so many Actions, this *Dura-Mater*, has many of its Nerves from the Fifth Pair, as the said *Vieussens* has shewn in several Places; so that that is likewise moved thereby.

S E C T. XXV. *The Eighth Pair produces the same Effects.*

Thirdly, I T may be likewise observed from the said *Vieussens*, p. 347. that in many Cases, the Nerves of the Eighth Pair, which the Ancients name the *Wandering Nerves*, or *Par vagum* encompass those of the Fifth Pair in their Operations; and consequently in many Places, by the interposition of the Nervous Branches, those of the Eighth Pair are inserted in the Intercostals which proceed from the Fifth Pair. And how much therefore those of the Eighth Pair do likewise help to excite the Passions, appears from the same Author, p. 347, and 348. where he says, *Since the Eighth Pair has a Communication with the Auditory Nerves about the Origin thereof, we find the Reason why not only different Passions are excited in the Soul, according to the differences of Sounds, but also why the Heart and other Parts, yea, even the whole Body, are variously affected thereby.*

SECT. XXVI. *The Auditory Nerve produces the like Effect.*

Fourthly, We find the aforementioned Monsieur Vieussens, discoursing about the Auditory Nerves in the following manner; *These Auditory Nerves rise close to the Root of the Eighth or Wandering Pair, with which the softer Branch of the said Nerves runs along; whereby it comes to pass, that there is such a great Sympathy between the Ear and the Bowels, which are provided with this Eighth Pair. That according to the variety of the Sounds, various Motions are produced not only in the Brain, but likewise in the Breast, and oftentimes in the whole Body, and thereby (viz. on occasion of these Motions) various Notions and Conceptions are excited in the Soul.*

Besides all this, it is likewise found that the harder Auditory Nerve is likewise inserted in the Eighth and Fifth Pair, and also sends a Branch to the *Dura-Mater*, besides those which it gives to the Instruments of Hearing. See Vieussens, p. 340, and 341.

SECT. XXVII. *The Motion of the Chorda Tympani does likewise excite the Passions.*

FROM all which it is therefore plain, that by the Motion of the Fifth Pair, and by that of the Auditory Nerve, our Passions are excited; and that the Fifth Pair produces this Effect both from itself, as it sends several Branches to the *Dura-Mater*, and a great many to the Eighth Pair, which Eighth Pair does likewise excite the Passions: The Auditory Nerve also has the same Effect, because it is inserted in the Fifth and Eighth Pair, and in the said *Dura-Mater*.

Now

Now forasmuch as it has been already shewn that the Drum-Membrane, which is moved by every Sound, can undergo no Motion unless the Auditory Bones, and by them the *Chorda Tympani* EO (*Tab. XI. Fig. 3.* and *C. 7. Tab. XII. Fig. 1.*) be moved at the same time; and forasmuch as *Du Verney* and *Valsalva* have both proved that this is a Branch lying between the Fifth Pair and the hard Auditory Nerve, and inserted in both; it follows, that this *Chorda* being always moved by Sounds, both these Nerves must likewise share in the same Motion: Wherefore it is Manifest, that the Operation of this *Chorda* does likewise, among other things, consist herein, namely to bring the Body into Emotions or Passions of Mind by these Nerves, or at least to dispose and prepare it for the same.

SECT. XXVIII. *Why the Hearing above all other Senses, is best adapted to these Purposes.*

THE *Sight* is commonly esteemed the most excellent of all the Senses; and Experience itself has made it a Proverb, That one Witness, who has seen a thing, is more to be credited than ten that have heard it; which may be the reason, perhaps, that the *Hearing* may be adapted by its Structure, even beyond the *Sight*, to stir up Passions and Emotions in Humane Minds.

But considering that the Great GOD, according to his endless Wisdom and Mercy, has thought fit to propagate Saving Faith in his adorable Son by the means of *Hearing*, as well before he took upon him Human Nature, as particularly after that he left this World and enter'd into his Glory: It seemed to me (if one may presume to say any thing of the Wise Design's of the Almighty, when they are not fully reveal'd to us) for these Reasons, that the Instruments of Hearing have received such a
different

different Contexture from those of all the other Senses. For, in order to adapt them for so unconceivably a great Work, the following Properties are necessary thereto.

First, That the Hearing, among all the Senses, should have the Faculty to represent to the Mind absent Things, either future or past, by the means of the Sound of Words, and to make us comprehend them as if they were present; whereas the Sight, and other Senses, are only affected by Objects that are present to them.

Secondly, That the Instruments belonging to the Sense of Hearing, have moreover such a particular Structure, whereby they are enabled to excite all our Passions and Inclinations, and to awake the Powers of our Minds.

The first Property is proved by Experience; the second has been already shewn by the Description we have given of the *Chorda Tympani*, and the other Instruments of Hearing, to which might perhaps be added, as another Cause, *First*, that the Drum-Membrane itself consists of the Union of two other Membranes, one of which is the Skin of the Auditory Tube, and the other a Part of the *Dura Mater* which extends itself thereto. *Secondly*, that the Air which is put into Motion by Sound, can immediately affect the *Dura Mater* by the little Holes in the Cavity of the Drum, and by the Tube which is continued from thence to the Palate. These Discoveries we owe to *Valsalva*. But this we leave to the further Considerations of the Learned; Let it suffice here, that it has been plainly enough proved, that those Instruments that belong to the Sense of Hearing are adapted to excite the Passions.

S E C T. XXIX. *An Experiment to shew the Force of Musick.*

IN the *History of the Royal Academy in France*, for the Year 1717. (under the Head of *Observations upon Physicks in General*) we find a Relation of a great Musician, and in the Hist. of 1708. of a Dancing-Master; the first of whom was taken with a continued Fever and great Ravings; and the last with a very violent Fever attended with a kind of Lethargy, and afterwards with Madness; and that both of 'em were perfectly restored to their Senses by Musick.

We also find several Observations made upon Persons that have been stung by a *Tarantula*, a Creature found in *Italy*, of the Shape and Size of a great Spider, which has produced the extreamest Disorders in their Understanding, Motions and Powers of Life; the Faces of some turning back, their Feet and Hands as if they were Dead; others lying Speechless, or in deep Melancholy, seeking Solitary and Burying Places; sometimes digging Pits and Holes, which they fill with Water, and wallow in the Mud thereof like Swine; finally, after having undergone innumerable Miseries, their Distempers have only ended with their Lives.

I shall not enquire into the Causes thereof, but we are taught by Experience, that this Great Evil, for which hitherto no other Remedy is known, can only be cured by the Sound of Musick, of which different Airs and Tunes must be played, according to the different Nature and Colour of those *Tarantula's* that have given the Wounds.

They that desire a fuller Information of these Matters, may be pleased to consult what Signior *Bagliovi* has said about it.

Whilst I was writing this, a certain Learned Gentleman, and a Great Master in Musick, did me the Honour of a Visit ; and, as our Discourse occasionally fell upon this Subject, was pleased to inform me that the famous *Italian* Musician, *Angelo Vitali*, had related to him the following Story, and assured him of the Truth of it : Namely, that a certain Player upon the Lute at *Venice* had boasted, that by his playing he could deprive the Hearers of the use of their Understanding ; whereupon he was sent for by the *Doge*, who was a Lover of Musick, and commanded to put his Art in Practice before him ; where, after having played some time very finely, and to the amazement of the Hearers, he at last began a mournful Tune, with a Design, as far as he was able, to put the *Doge* into a melancholy Humour, and presently after, he struck up a jovial one, to dispose him to Mirth and Dancing ; and after having repeated those two kinds of Tunes several times by turns, he was order'd by the *Doge*, who seemed to be no longer able to endure those different Emotions which he felt in his Soul, to forbear Playing any longer.

Now that such sudden Variations in Tunes, by which Men are in one Minute's time render'd very Sorrowful, and the next no less Merry, do produce strange Effects upon our Minds, may easily be conceived by those that have ever felt the Power of Musick from an able Hand : At least, it is very plain from hence, and from numberless other Instances, how much the Sense of Hearing contributes towards exciting the Passions.

S E C T. XXX. *The Force of other Sounds.*

HowEVER, let no body think that nothing but good Musick is capable of exciting Passions and Disorders in the Minds of Men, since we have seen the like Effects produced by other Sounds. Every body can furnish Instances of the extraordinary Emotions and Passions which the Noise of a Drum, and the Discharge of Guns, do excite in the Souls of those that have been in Sieges or Engagements by Sea or Land.

Physicians likewise meet with many such Instances in their Practice. Thus we see Women that are troubled with Hysterical Fits oftentimes upon the shutting of a Door, the falling of a Book, or any other unexpected Sound, very much disturb'd and frighten'd, so as to start or leap at it.

I have met with some, that being troubled with this grievous Distemper, are not in a continual Fright, but complain very often, that they fancy they hear the common Voices of Men just as if they were the shrill Sounds of a Great Bell continually ringing in their Ears, which made them ready to faint.

C O N.



CONTEMPLATION XIV.

Of the Senses of Tasting, Smelling and Feeling.

SECT. I. *Of the Necessity of the Taste.*

NOW as the great Creator is wonderfully Wise and Gracious in adapting us to the Senses of Seeing and Hearing, he is not less so in the Manner by which he makes our Meat and Drink, the two necessary Supports of a decaying Life, so agreeable to us.

It seems very unreasonable and improbable, that any body should be negligent in the seasonable Use of Food ; but, unless it had also pleased the Goodness and Loving Kindness of our adorable Creator, to bestow upon us the Sense of *Tasting*, and thereby to render the trouble of Eating and Drinking grateful and pleasing to us, there seemed a Danger that many People would have consider'd it as a Burden and Slavery, and would therefore have often let it alone, at least, they would not have used it in due Time or Quantity. And this will not appear strange to any Body that has ever observed with how much Aversion, and many times with Loathing too, we are brought to the use of Medicines, which, with respect to the necessity of 'em, do far exceed Food itself.

S E C T. II. *The Seat of Tasting is in the Mouth.*

N O W can any Man think that it happen'd without the Wisdom of the Creator, that the Sense of Tasting should be just placed in the Mouth, in which all Food is at first received, masticated, or made small by Chewing, and moisten'd with Spit-
tle, and no where else ?

S E C T. III. *Several Notions about the Instruments of Tasting.*

B U T, in how great Darknefs the Ancients were, with respect to the true Instruments by which this Sense of Tasting is performed in us, and how doubtfully and variously even the Modern Enquirers have writ concerning them, may be learned from the Letter of *Malpighi de Lingua*; some placing the true Instrument of Taste in the upper Membrane of the Tongue; others in the spongy Membrane thereof; others again in the Nerves that are spread throughout the whole Tongue; some in the Almond-Glands, and their extended Membranes; others in the Throat; a few in the Palate, which last have been entirely confuted a few Years ago, by the Learned *Bobnius, Circul. Anat. p. 375*. At present most People place them in those little Protuberances, which they call the *Papillæ* or *Nipples*.

S E C T. IV. *The Instruments of Taste.*

W E shall not let ourselves farther into this Matter, which perhaps may be hereafter cleared up by more Experiments, but only say, that the last of the above-mention'd Opinions is esteemed the truest, by the greatest Enquirers into Nature
among

among the Moderns. We see then, that the Structure of the little Nipples appear peculiar in the Tongue above other Parts, and that they have such a singular Form, as seems to be required for one of the external Senses: since it is probable, that in the Tegument of the Tongue, these Orifices were expressly made in order to admit into them the Particles of Food moisten'd by the Glands, and to convey them to the *Papillæ* that lye there-under, whereby they are affected with that Sensation which we call *Tast*.

For which purpose the accurate Dissections of the above-mention'd *Malpighi* and others, have shewn, that the Nerves of the Fifth and Ninth Pair, which are held to be the Nerves of Tasting, are inserted in these *Papillæ* after a particular manner, and seem chiefly to form this whole Nerve and Papillous Body; accordingly (as it is likewise observed by the same *Malpighius de Lingua*, p. 16.) we find, that the Nerves that are adapted to one of the external Senses, are at last dilated into a flat and membranous Body.

Now in what manner soever all this is of use to the Sense of *Tasting*, we may at least observe here likewise, the wonderful Wisdom of the Creator, who has been pleas'd to lodge in the Parts of the Mouth such Instruments as are proper to excite in us this sensation of *Tast*; of which, tho' the Structure were perfectly understood by Anatomists; yet the most skilful of 'em all could never be able so much as to guess how the Soul would be affected thereby, had he not before-hand been taught by continual Experience, what it is to *Tast* a thing. And can any one fancy that so Necessary, so Wonderful a Texture derives its origin from *meer Chance*, or the *ignorant Laws* of Nature?

S E C T. V, and VI. *Experiments to shew that the Taſt is in the Palate.*

THE famous Enquirer into the Secrets of Nature, *Malpighi*, has discover'd *Papillæ* or Nipples in the Palate, or Roof of the Mouth, and in the Cheeks alſo; ſo that according to his Hypotheſis, the Palate, being likewise provided with the true Instruments of Taſt, muſt neceſſarily have that Senſation alſo.

To this we may add, that the later Writings of the Profeſſors *Bergerus* and *Hoffmannus*, publiſhed ſince the Year 1700. do alſo poſitively aſcribe the Taſt to the Palate, affirming, that *Pliny* in his Natural Hiſtory has done the ſame; but they are particularly induced thereto by the afore-mention'd Obſervations of *Malpighi*; and farther, by the account we have in the third Year of the *German Ephimerides*, of a Child of about 8 or 9 Years old, in lower *Poiſſon*, who in the Small-Pox loſt his whole Tongue by a Cancer, and ſpit it out by Piece-meal; inſomuch that at laſt there did not remain any Sign that he had had one. Notwithſtanding which, this Child did not only Speak, Spit, Chew, and ſwallow his Viſtuals, but could likewise Taſt, by the remaining Structure of his Mouth; and (as the Author, who was a Surgeon of *Saumur*, ſays *cb. 8.*) he could diſtinguiſh all kinds of Taſts very well; whence the Writer farther infers from *Pliny*, that the Taſt muſt alſo belong to the Palate.

BUT ſince this is a thing in which Experience, as in all others, ought to be the Judge, and as the tryal hereof may be eaſily made; Let a Man only take a little powder'd Sugar, Syrup, or any other ſweet Matter, and lay it upon the Tongue; and as ſoon as ever they are melted he will begin to Taſt; probably, becauſe they then begin to pene-
trate

trate and sink into the Orifices of the upper Tegument of the Tongue, with the moisture of the Spittle, and so irritate the Nervous *Papillæ* that lye under the same.

But if he proceeds farther, and endeavours to swallow the sweet Matter when 'tis melted, and to that End, presses it with the Tongue against the hinder Part of the Palate, he will plainly find, that that Part is likewise affected with the Sweetness; and especially, if after such Swallowing, he presently draws the Tongue back again to the Palate, keeping it down in such a manner that it cannot touch the same, he will find, that when afterwards the Taste of the Sugar does act upon the Tongue a little more sensibly, the Palate will be also more sensibly affected with it for a time. From whereby, at least, of how little moment soever this Experiment is, all those disagreeing Notions seem to be over-thrown, and the Opinion, that the Sense of Tasting is likewise in the Palate, is established upon them.

SECT. VII. *The Instruments of Smelling.*

NOW to pass on to the Sense of Smelling; Can any one without acknowledging the Wisdom and Goodness of GOD, observe, that whereas the Bone of the Head is otherwise so hard, the Nerves of Smelling have a Bone to themselves, which, in order to afford them a Passage, is full of little Holes like a Sieve, and which is therefore called the *Spongy* or *Sieve-like* Bone; thro' which the said Nerves transmit their little Threads and Branches (being there encompassed by the *Dura-Mater*) to the Papillous Membrane or Flesh, as some call it, which lines the Cavities that are in this Spongy-Bone, and in the top of the Nostrils, and which Nerves are expanded therein, in order probably to com-

pose the Instrument of Smelling ? For that this Instrument, which produces Smelling, is not below, but at the top of the Nostrils, appears from hence ; that in order to Smell, a drawing in of the Breath is necessary, whereby the Particles of the Olfactory Matter being mingled with Air, must strike with some Force against the Papillous Tegument, to produce the Sense of Smelling : And every one that holds his Breath, tho' never so little, can easily experience, that tho' any Smell be brought under his Nose, yet he is not affected with it, till he draws in his Breath again.

This Experiment seemed indeed too trifling and too well known to be mentioned here ; were it not that a certain Learned and Ingenious Author had denied the same. From whence again, as above, in the Business of Tasting, the Weakness of all that is Humane does but too easily appear.

SECT. VIII. *Convictions from the foregoing Observations.*

Now, can any one that is endowed with Reason deny the wise Dispositions of these Instruments, namely, that since the Olfactory Particles are convey'd by the Air, the Instruments of Smelling are to be found exactly in the Place thro' which the Air continually passes and repasses on the account of Respiration ? That they are placed just over the Mouth to communicate to us, at the first, by this Sense of Smelling, some Knowledge of the Qualities of Meat and Drink which we are about to use ? That the Nostrils are broader at the Bottom, that they may receive so much more of the Olfactory Particles ; but narrower at the Top ; to the End, that by the Compression of those Particles, the Olfactory Membrane and Nerves may be the more powerfully affected therewith ?

SECT.

SECT. IX. *The Sense of Feeling.*

BESIDES the foregoing Senses, the Instruments of which are all disposed in their proper Places, there is one more, which is called the *Feeling*, which is in a manner distributed throughout the whole Body, especially, if we understand thereby the Sensation of Pain: But if we do not extend it any farther than to that Power or Faculty by which, when we touch any Bodies without us, we are enabled to discover the Roughness or Smoothness, the Solidity or Fluidity, and other Qualities thereof, we can only then suppose the Seat of this Sense to be in the Skin. Accordingly, we know that this latter is distinguished in the Latin Tongue by the Word *Tactus*, or Touching; and that when we would mention the Sensation of Pain, we express it by the Word *Sensus*, and not *Tactus Doloris*.

SECT. X. *The Instruments of Feeling.*

Now that this last, that is to say the *Touch*, is only Seated in the Skin, which is naked and exposed to the Objects that are without us, is sufficiently known to the Modern Anatomists; as also, that there is in the Skin a Disposition and Contexture analogous to that of the Tongue, which the diligent *Malpighi* and others, find to consist (besides the Blood and other Vessels) of Glands, each of which has a little Receptacle or Hole that is open externally, and affords a Passage to the Sweat and Perspiration: From whence it comes, that there arise outwardly from the said Skin little Pyramidal Protuberances, like Nipples, which are encompassed and fasten'd together by a Reti-formous

mous Body lying between the *Cutis* and the *Cuticula*.

These *Papillæ* or Nipples, are what have been of late Years, and with great appearance of Truth, accounted the Instruments of Feeling, because the Microscopes seem to inform us that they spring from the Nerves, the Branches of which are inserted very thick in the Skin, and are more numerous in Proportion, than those that run to the Muscles or any other Parts, as the great Describer of Nerves, *Vieussens*, has shewn in his Preface concerning them. It is likewise plain from hence, by the help of the Microscope, that these Papillous Protuberances make the upper Skin rise in many Places, to the End, that it may be so much the more easily affected by the Contact of External Bodies.

S E C T. XI. *Convictions from the foregoing Observations.*

How useful now this Sense of Feeling is to Mankind in numberless Cases is sufficiently known; and the more, because every one that wants it, is in many Accidents disabled from preventing his Ruin; as has been found in one, who having lost the Sense of Feeling, together with Motion, on one side of the Body, and setting too close to the Fire, was miserably Burnt before he was in the least aware of it. Can then an *Atheist* say, that he is not bound to be very thankful for so great a Benefit as this Faculty is, whereby he is immediately made sensible of any violent Heat, and consequently enabled to avoid the same and many other Inconveniencies? Or will he say, that it is a simple and ignorant Cause that has bestowed this Sense of Feeling not only upon one Man, but like-
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wife upon all, and fixed it not in one only, but in all the Parts of the external Skin.

SECT. XII. *The Fingers and Palms of the Hand have a more acute Sense of Feeling than other Parts of the Body.*

Is it without Design, that in those Parts in which we explore and feel external Objects, this Sense is much more fine and tender than in those which we seldom use for that Purpose; for it is known to every one, that a Man feels more accurately with the hollow or Palm of the Hand, or the tips or extream Parts of the Fingers, than in most other Places?

And this is one of those Reasons from whence it is inferr'd, that this Papillous Body which lies between the Skin and the upper Membrane is the real Instrument of Feeling: Since it appears by experience (according to the Testimony of *Malpighi*, and after him of *Bohnus*, *Bergerus*, and others) that in those places, namely, the Palm of the Hand and the Tops of the Fingers, which above other Parts are particularly useful in Feeling, there is likewise a greater Collection of these *Papillæ* or Protuberances, than in the other Parts of the Body, which are not so frequently used for that purpose. It is likewise observed by *Bergerus*, that these *Papillæ* are much more numerous, as well as large, at the Tip of the Tongue, and in the Lips; and that these Parts do feel more accurately, as it is necessary they should, to the end, that they may immediately discover when the Food is too warm or prejudicial any otherwise.

SECT. XIII. *Convictions from what has been said above, concerning all the External Senses.*

WE do now here intreat all such as still seem to doubt of the Wisdom, Goodness and Power of their great Creator, yea, even the most unfortunate and obdurate Atheists, in case they can or will receive any kind of Instruction, that they would seriously consider with us this wonderful Disposition and Structure of the Senses, and the vast Advantages accruing thereby, not only to one, but even to all Men who are in Health: And then let 'em say, whether they can still maintain with a good Conscience, that the Greatness and Goodness of Him that formed them, does not shine out as brightly, yea, and more too in all these things, than the skill of an Artificer in the Construction of any curious Machine.

When he considers that the Smell and the Taste do likewise serve to inform us, not only of the good and bad Qualities of our Food, but that the Pleasure which we find thereby excited in us, is an inducement to undergo this daily and continual labour and trouble of Eating and Drinking; will he say, that this happens by Chance, and that he is not at all indebted to Providence for all this? That is to say, for such noble Exhalations and Perfumes that proceed from so many Plants, Herbs, Flowers, Gums, Spices, and other Things; for such a variety of agreeable Tastes, which he daily enjoys from all those Eatables and Drinkables that serve for Food and Refreshment to us.

When he sees that several Parts belonging to our Bodies, such as Bones, Nails, Hair, Teeth, so far as they are naked, have no Sensation in them, and yet our whole Body is encompass'd externally with a Covering and Skin which has the Faculty
of

of making known to, and informing us of every Thing that does sensibly approach and touch it. Can he think such a Structure as this is brought about without any wise Design, and will not any intelligent Person think it unconceivable?

When he considers, that the great Wonder of the Sight enables him to contemplate the Sun, the Moon, and even those Stars that are at an unconceivable Distance from him; and that this Sense is adapted to an Enquiry into the Magnitude and Motion of such glorious Creatures, and to observe their Laws and Properties; that this Sense of Seeing can impart to him the Knowledge of many Things that are out of the reach of all the other Senses; that its Instruments are of so wonderful a Structure as has been already shewn: That to the end, that nothing may be wanting to render this Sense compleatly useful, the immensurable space of the Heavens is every where filled with Light: And particularly to the end, that this Sensation should not be produced in Men without Pleasure and Agreeableness, the unconceivable number of Rays of Light is divided into so many kinds, either of Figure or Motion, as represent to us all visible Objects with the most pleasing Colours. Can he still fancy, that there is no Design nor Contrivance in all this; and that such a wonderful Order and Regularity of every Thing, with respect to each other, whereby Light is thus adapted to the Eye, and the Eye to Light, are all of 'em the result of Causes working together without Order, and without Understanding? Let him once again ask himself these Questions in his most serious Retirement.

The rather, if he observes, that the Hearing informs us of the Motion and Percussion of Bodies; of which we oftentimes can get no Knowledge by other Senses; no, not even by the Sight: That there-

therefore, since the Light does only cause us to see such Objects as are before us, the Rays of it only moving in Right Lines; the Hearing warns us of Things that are round about us, and such as are sometimes even concealed from the Sight, because Sounds pass thro' all imaginable Curvities.

Without this Sense of Hearing, how great would the trouble be in communicating our Thoughts to each other? What Inconveniencies would occur to every one in Learning of Arts and Sciences, in Trade, in Pleading and other Worldly Affairs?

Now can any one be convinced from the Structure of a Watch, a Mill, a House, and Thousands of other Artificial Machines, that the Maker of them propos'd to himself some End in the formation of them; and yet with a safe Conscience impute to *meer Chance* the amazing Texture of the Instruments of *Hearing*? And the rather when he considers this Globe of the Earth surrounded with an Ocean of Air, of which one of its Uses is to convey *Sounds* to our Ears?

Let therefore one of the most conceited Philosophers, one of the most *Strong Minds*, in his own Opinion, or rather one of the most to be lamented Atheists, tell us here, in case he had always wanted one of his Senses, for instance, that of the Sight, whether, by the help of all his Philosophy, he could ever have known or learned what a sort of Sensation that was, or how Men are affected with that which we call *Seeing*.

Let him make known to us, since the Bodily Instruments of all our Senses are all equally produced by, and do consist of the same Bread, Water, and other kinds of Food, how it comes to pass, that his Hand has not the Faculty of Seeing as well as his Eye; that his Foot does not hear as well as his Ear, altho' the Light and the Air may be made to fall upon those Parts in the same Figure and Motion.

tion. Can any one think, that their different Forms produce such Sensations? Let him then shew us how they do it: Let him examine his Meat and Drink after all imaginable Ways, and tell us the reason, why the same Bread in the Ears becomes an Instrument of Hearing, in the Tongue of Tasting, in the Nose of Smelling, and in the Skin of Feeling: He must resolve it all into the absolute Will of that adorable Creator, who is unfathomable in these his Ways, and who communicates to our Souls the Knowledge of these Things, in so wonderful a Manner. He must therefore be stark Blind that does not discover G O D in all these Senses.

Is there no Design nor End to be observed in all this? Let then an unhappy Atheist tell us, if he had a mind to make himself or any other Person happy, and had the Power to do it, whether he would not endow them with every one of the Faculties that are found in these Senses: And in case he could have produced any Thing like them, tho' in a much lower degree of Perfection, by his Skill and Ingenuity, whether he would not think it a very great wrong done to him, if some Body, judging of his Performance, should not, or would not see the Wisdom and Contrivance of the Maker therein. And can he still remain insensible of his own Blindness, who declines to acknowledge the same in so astonishing a Machine, as that of Humane Bodies? The rather, whilst he perceives, that in order to render all our Senses compleat and perfect, *Air, Light, Plants, Living Creatures*, and the whole *Universe* almost, must contribute thereto.

If then the Contemplation of all this cannot induce him to acknowledge his Maker's Goodness, and his own Obligations on these Accounts, with the utmost Gratitude; let him but consider with himself in what a deplorable Condition he would find

find himself and every Thing besides, if Mankind were deprived of these Effects of their Creator's Favour, which appear in all their Senses: And let him for once suppose, that there was a Man who having none of these External Senses, did neither *See, Hear, Smell, Taste*, nor *Feel*. Now, tho' a Man were always to live thus, even in good Health, could he sufficiently express the Miseries of such a State? He that rightly weighs it, would he not rather wish to be Dead, or to have never been Born, or even to have been a Stock or Stone, than which he is but little better in such a State? Now if without this Mercy of God, the Misery of every particular Person would have been so great; to what shall we compare that of the vast Number of Men, who together make up all the Nations of the Earth, in case there were to be found upon it no other Creatures, but *Blind, Deaf, Insensible*, and so forth?

Have we then bestowed upon ourselves these Perfections of the Senses? No certainly. Has then mere Chance been able to do it? By no means; for Chance is disposed to Act as well one way as another; and yet we find, that far the greater Part, yea, all sound People, are born with all these Senses.

Let therefore a miserable Atheist confess, that he is not only ignorant, but that he must likewise for ever remain so, of the manner in which our Senses are produced, and do operate in us. All of them consist in a Motion and Impression that external Objects make upon us; all of them consist of a Motion or Passion of some of the Parts of our Body; all of them consist of Instruments produced by the same Meat and Drink; and, according to the best Philosophy, all of them seem to result only from a various Motions of the same Matter.

Whence then proceed the different Conceptions which we find in ourselves, upon *Seeing, Hearing, Tasting,*

Tasting, Smelling and Feeling? Must not then the Atheist, since there can be no other Subterfuge, acknowledge that there is something Immaterial in us, which is the Cause thereof? Let it be so: But if it be Incorporeal, how can it be moved by something that is Corporeal? For there is nothing but Bodies and Motions, both in the Matters round about us, and in the Instruments themselves of our Senses: Will he say then, that a Soul cannot be moved because it is Incorporeal? How then does it happen, that a Substance, which can neither be moved, nor touched by Bodies, is yet affected by, or thro' the Motions of Bodies; and can *See, Hear, Taste, Smell* or *Feel*? For that it is so in Fact, cannot be denied.

I think we need not use any farther Arguments to drive an Atheist into a Confession of his total Ignorance. And if he does not know how all these Things come to pass, as his own Conscience must convince him that he does not, how can he, if he would be taken but for a tolerably Wise Man, pretend to maintain it for a Truth, that a Thing, which he does not know how it happens, can be produced by the necessary and ignorant Laws of Nature; Let him reflect upon all the Things most seriously with himself, before he proceeds any farther.

If then this is only to be ascribed to a Powerful, Wise and Gracious Creator, who, that has the least spark of Gratitude or Generosity in him, can forbear owning these Benefits with a Thankful Heart? And even tho' it were an Atheist himself, could he persist in Blaspheming a GOD that had accumulated on him so many Favours, and in denying all his Attributes, yea his very Existence, must he not expect to feel at last the Vengeance of that Power which he had so long opposed?

SECT. XIV. *Farther Convictions from the limited Powers of our Senses.*

I have often contemplated with the deepest Humility, not only the afore-mention'd wonderful Structure, and invaluable Advantages of our External Senses, but likewise the unsearchable Ways of our great Creator in determining and bounding the same. The unhappy Philosophers may fanfly perhaps to cover themselves against the Stings and Reproaches of their own Consciences, by objecting, that since so Powerful a Being has so bountifully bestow'd such Perfections on Mankind, by adorning them with the Faculties of the external Senses, why has he not distributed the same in equal degrees of goodness to every individual Person, to which we see some of 'em afterwards attain, by the help of outward means?

In answer to which, we shall not stop here to shew, that it does by no means agree with the condition of any one who is nothing but a *Creature*, to prescribe Laws to his great *Creator*; and in case a Pot should say to the Artificer who made it, why hast thou formed me thus? They themselves would deride the absurd Question: This is certain, that not one of these Philosophers is able to produce the least Argument, to shew that it is not much more equitable to confess with Christians, that we must only ascribe it to the Will of the Supreme Governor of all Things, that the Faculties of Men shou'd not rise to the highest Point of Perfection in this Life; and that his Wisdom reserves this for such only whom, in the approaching Eternity, he will vouchsafe to make proper Subjects for knowing his Attributes in the highest degree of Glory; rather than to think it a defect in the Power of him, who must be own'd Inscrutable in the Things he has already done.

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But let us likewise in our turn ask these Objectors another Question : must they not own that it would be an undeniable Token of the vilest Ingratitude, if a Man, that had receiv'd from another who ow'd him nothing, more Favours than he could have even desired or thought of, should observe afterwards that the Wisdom of his Generous Benefactor might have extended itself yet farther, and that his Power was infinitely greater, so that if he had thought fit, he could have endow'd him with more noble Faculties than what he had hitherto bestow'd upon him ; and thereupon make this unreasonable conclusion, that since he had not given him all he could, he therefore ow'd him nothing for what he had already receiv'd from his liberal Hand ?

But if all that we have already said concerning the Senses, be not sufficient to convince him, let us go one step farther, and shew, that even the Bounds themselves, within which the extent of the Power of outward Senses is confined, do likewise contribute to make us more happy, than if they could be extended a great deal farther, as in this last Age they are found to do, by the help of Artificial Instruments.

Let us suppose, that our Eyes had the Faculty of our Modern Microscopes ; it is true, that they would shew us a World of new Creatures ; a drop of Pepper-water, or Vinegar, and the Seminal Matter of Creatures would appear like Ponds or Rivers full of Fish ; the Scum of stinking and putrified Liquors, like a Field full of Flowers and Plants ; the Mites in Cheese, like great hairy Spiders, and a Thousand other Things in like Proportion ; but it may be also no less easily conceived what a Loathing of many Things, which in themselves are otherwise very good and useful, these Swarms of Insects would produce in us, which per-

haps would be more evident, if you had seen as I have, how some People viewing the Mites in a piece of Cheese thro' a Microscope, and upon one of these exceeding small Creatures falling off, suddenly snatch'd away their Hands, for fear it should fall upon them, which, by reason of the Smalness of the Creature, excited a general Laughter in some of the Standers by; but in others, more grave Reflections on account of the Wisdom of God, who has been pleased to conceal these Things from the naked Eye of Ignorant and Fearful People: And yet to bless the Discoveries of Men by the Inventions of New Glassses, so far, that the necessary Means should not be wanting to such as endeavour to look into these Wonders.

Moreover, would these Philosophers even dare to desire, that their own Eyes should be endowed with the Qualities of the best Microscopes in case they understood the Nature and Foundation thereof? And would they judge themselves more happy, by seeing an Object so small in itself, magnified to so large a Size? When in the mean time all that their Sight could extend itself to, would be contained within more narrow Bounds than that of a Grain of Sand; nor would they be able to see any Objects plainly and distinctly, but such as were at no farther Distance from their Eyes, than one or two Inches: And as for all other Things that were more remote, such as Men, Beasts, Trees and Plants, to say nothing of the Sun, Moon and Stars, those sublime Creatures, they would either be entirely invisible to them, or would appear at least very confusedly; yea, if all this were so, and that the natural Sight could penetrate as far as the finest Microscopes, none that have ever experienced the same can deny, but that, by the help of them, one may see Bodies compounded of a Thousand little Particles; and consequently, that in order to see
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every Thing truly, and in its Original or last Parts, the Sight must be still extended inconceivably farther than such Microscopes have yet been able to carry it.

Now, on the other hand, suppose our Natural Eyes to be great Telescopes, like those that have enabled us to observe so many new Stars in the Heavens, and make so many new Discoveries in the Sun, Moon and Stars, they would be again liable to this Inconvenience, that they would be of very little use in seeing the Objects that surround us, as they would likewise not a little obstruct the Contemplation of all other Objects upon the Earth, because they would see too much of the Vapours and Exhalations continually rising from the Ground, which, like great thick Clouds, would hide every other visible Matter; as is but too well known to such as use these Instruments.

Thus likewise, if the Sense of *Smelling* should be as acute and nice in Men, as it seems to be in some kinds of Hunting Dogs; no Person, no Creature, could ever meet us, nor could we pass by any Footsteps of them without being strongly affected with the *Effluvia* that proceed from them; and we should be forced to turn our Attention, tho' never so much against our Wills, and tho' we ought to apply it to more exalted Objects, I say, we should be compelled to fix it upon these contemptible Matters.

In case the *Tongue* should make us Taste Food of the lowest flavour, with as high a Sensation as now the strongest and finest *Ragouts*, or made Dishes do produce; there need no farther Proof to induce every one to confess, that this alone would suffice to render such Food very disagreeable to us, after having used it but a few times.

Could the *Hearing* so nicely observe all Sounds, as it is now found to do, when, by the help of the

Long Tube, or Speaking Trumpet held to the Ear, any Body Whispers softly into the Broad End of it; how little Attention would People have for some Things? Certainly no more than we have when we find ourselves in the midst of a confused Noise and Bawling of a great many Voices, or the loud Peals of Drums and Guns. They that have ever been witnesses of the Inconveniencies that Sick People undergo by Hearing too acutely, will easily be convinced of this Truth.

If the *Feeling* were so tender and nice in all the Parts of the Body, as we find it in the most sensible Places, and in the Membranes of the Eyes; must we not own that we should be very unhappy, and suffer a great deal of Pain too, by the touch of the lightest Feather?

To conclude; can any Body reflect upon all this, without acknowledging therein the Goodness of his Maker, who has not only furnished him with such noble Perfections, as are the external Senses, for want of which, he would not be better than a Stock; but who has likewise out of his adorable Wisdom, included these Powers within such Bounds, without which they would have been no other than burdensome to us, and a perpetual Obstruction in the attentive Contemplation of greater Matters?

If it should appear to some, that we have dwelt longer upon this Subject than is perhaps agreeable to 'em; let them be pleased to remember, that our Principal Design throughout this whole Work, is to represent to *Infidels* and *Atheists*, the Wisdom and Goodness of their Creator, which shines out so brightly in the external Senses of Men, and the unconceivable Faculties, or Properties thereof even to those that are afraid of being convinced thereby; and in which the Adorable Author of all these Things has most evidently shewn that he ought to
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be distinguisht in an illustrious manner from *meer Chance*, and yet more, from Necessary Laws, or from a Nature that works without Knowledge or Understanding.

Nothing more seems requisite towards an irrefragable Conviction hereof, than that what all the Learned, as well as we, have advanced concerning the Senses, should be silently, attentively, and impartially weigh'd: when perhaps he that has so Bountifully bestow'd them, may vouchsafe to Bless the Means for the Conviction of those who have hitherto doubted of these Important Truths.



CONTEMPLATION XV.

That the Union of Soul and Body is unknown to us : Convictions from thence.

SECT. I. *The Union of the Soul and Body unknown to us : Convictions from thence.*

NOW since each of these External Senses do lead us up to the Soul; can there likewise be any Person so unhappy, as truly to reflect upon this Wonder, surpassing the Conception of all the Philosophers, this most astonishing Manner, after which the Body is united to the Soul, without being thereby convinced of the inexpressible Power and Wisdom of Him that made 'em? Of Him, who has shewn himself in this, as well as in many other Things, after a glorious Manner, both Wonderful

and Adorable; who, whilst He thus Works in Ways unfathomable by all Men, does likewise compel even his Enemies to be Witnesses thereof.

And tho' others may think that they can form any Notions thereof; yet an Atheist must confess, that there is something in it which is perfectly unintelligible to him.

For suppose he should boldly maintain, that the Corporeal Matter (in which, however, he can shew us nothing but Motion) has the Property of Thinking and Understanding; let him tell us, and prove to us, what Composition of Parts, what Force, what Swiftneſs, what Limits and Directions of Courſe, either according to right or crooked Lines, are required in Matter thus moved, to render it capable of Reasoning and Comprehending a Mathematical Demonſtration. And we ſhall not need to ask him, whether this ſurpaſſes his Underſtanding.

Or, ſuppoſe alſo, that he ſhould, according to Reaſon and Experience, affirm, that his Soul is Incorporeal; let him ſhew us, how it comes to paſs, that a Soul being Immaterial in its Exiſtence, and which, according to all the Notions we are wont to form of it, can neither touch nor be touched by a Body, and yet can be affected *by, or through, or according to* the Motion of the Body (for we ſhall not here diſpute about the manner of it, that being not neceſſary with reſpect to Atheiſts) and *vice verſa*, how the Soul can affect and move the Body, or at leaſt adminiſter Occaſion thereto, which, for the foregoing Reaſons, we need not now examine: So that by its mere Will, the Body being in good Health, the ſtretching out the Hand, for inſtance, immediately follows; and if that Hand ſhould be burnt, the Soul immediately feels Pain. Now if all this were not as certainly known to him, as the moſt certain Thing in the World is, for aſmuch as he can

be every minute convinced thereof, by repeated Experiments, would not he be tempted to look upon so disagreeing Notions, and which have not the least Analogy to one another, as gross Falshoods and vain Conceptions of the Brain? Wherefore, whatever an Atheist may fancy to himself, the manner of the Union of the Soul and Body must always remain inconceivable and unintelligible to him.

I know very well, in case we proceed no farther, that the great Disagreement, concerning the manner in which the Body is moved by the Will, and which has occasion'd many Controversies among Great and Wise Men, must be left undetermined by us: But neither is this the Place, nor yet the Time, to say any Thing about it, since we only write for the Conviction of Atheists; whereas the others, howmuch soever they differ in their Opinions, do all agree in the Belief of a G O D.

And we don't think it sufficient to have shewn here, that whatever an unhappy Philosopher, who owns no G O D, may say or think concerning these Matters, it all terminates in being Incomprehensible, if he will satisfy his Ideas and undoubted Experiences; which was our only Design at present.

Let the Atheist therefore learn in the terror of his Heart, that there lies an irrefragable Proof in what he finds in himself to be undeniable, that his Reason and Ideas, as much as he relies on them, are utterly incapable to inform him of the just Disposition, and the manner in Acting of Things that exist without him, according to Truth; and then consider whether it be safe for him to persevere in Blaspheming, or Denying a God so incomprehensibly Mighty and Powerful.

At least can he, or any one else pronounce that the Things of which he acknowledges not to understand the manner of their Operations, are pro-

duced by meer Chance? And can Chance, or any Cause that is wholly Ignorant of what it is doing, and which works without Laws or Rules, produce Things of so great moment, and so inscrutable even to the most penetrating Genius, so Frequently, so Constantly, and with so much Order? And what can the greatest Philosopher say of these Things, otherwise than that Experiencing daily that something happens in himself, which if it did not, he should think impossible, he is forced to own the Stamp of God's infinite Power, which is imprest on him, and upon all others, even those that deny or hate him, without their Concurrence, and against their Will. And perhaps it is no wrong Conclusion of theirs who maintain, that we do not yet rightly understand or know either our *Soul* or our *Body*, with respect to their true Nature and Properties. For if both of 'em were so fully known by us as some Philosophers imagin, how is it possible that any Thing can happen so plainly and sensibly between 'em both; as every one experiences in himself, and yet is so unintelligible, as to the manner of Acting, to all that have inquir'd into the same; insomuch that none have been able to say any Thing concerning them, which does not at last terminate in an absolute *Incomprehensibility*?

SECT. II. *Convictions from the foregoing Reflections.*

BEFORE we quit this Subject of the *Soul*, the greatest and most Precious Gift in the World, whereby it has pleased the infinitely Gracious Creator to render Men Happy: if an Atheist be not yet fully convinced how miserable he would have been himself, and all others with him, if God had not vouchsafed the Use of any external Senses, thereby excited to Thankfulness towards his Maker: Let him consider yet further what would have

have been the condition of Mankind, if none among them had been endowed with Understanding. What is a Man to himself; and what would all the Riches in the World have been to a Man in such a State? We find an illustrious Instance hereof in the History of that mighty Monarch of the whole Earth, as far as it was then known, the great *Nebuchadnezzar*, who upon the loss of his Understanding was not only debarr'd all Conversation with Men, but being thrust out of his exalted Throne by his own Subjects, was forced to keep Company with the Beasts of the Field.

And now suppose the whole World should abound with brutal, raving-mad Fellows, or be full of Fools and Idiots; or to express it in a Term that often comprehends it all, of drunken Sots, that had lost the use of their Reason; can any body reflect upon the unspeakable (how shall we call it) the sad and deplorable, or horrible and frightful Condition of all things, without wishing rather to be dead, than alive among such People? Now this invaluable Treasure, this precious Jewel of the *Understanding*, every one knows he is not able to bestow on himself. And can he imagin that he who indow'd him therewith, and that, without any help on his part, don't expect to be thanked for so great a Benefit?

SECT. III. *The Bounds of this Union.*

THIS Union of the Soul and Body is not only wonderful in itself, and in the manner in which it happens, but likewise in the Bounds and Limits which are prescribed to it. We find it thus in the first Place, that *the Soul does not operate by its Will* (however it be) *upon our whole Body*; or rather, *that our whole Body is not subject to the Soul in its Motions*, but only, as it should seem, those Parts that
receive

receive their Nerves from the *Cerebellum* and Back-Bone: Wherefore it is only our Arms, Hands, Legs, and all those Members with which we are said to act freely, that are moved according to the Pleasure of the Soul; whilst other Parts, which have their Nerves from the *Cerebrum*, and which do only serve for Life and the Support thereof, as the *Heart*, the *Arteries*, the *Stomach*, the *Bowels*, &c. do by no means obey the Will of the Soul, nor, like the former, can be moved or stopt at Pleasure.

Secondly, *Neither does the Soul feel when every Part of the Body is acted upon, or affected.* Thus we find, that besides the *Hair* and *Nails*, the *Bones* themselves are likewise insensible; all which make up a great Part of our Body: Not to mention that the *Lungs* are known to waste away in many Men without Pain; and that Chirurgical Observations teach us, that the Substance of the *Brain* may suffer very much, without communicating any Sensation thereof to the Soul.

SECT. IV. *Convictions from thence.*

CAN now a deplorable Atheist think he has so much cause to accuse the Christians of Credulity, when he hears them make the following Conclusion from the above-mention'd Premises: That since no Body can justly ascribe all this to mere Chance, working indifferently one way as well as another, this is a true and convincing Proof, that it can by no means proceed from a necessary Series of Laws of Nature, always acting after one and the same manner, that the Soul shou'd have the aforesaid Relation or Respect to the Body: Forasmuch as the Wise Creator being desirous to convince us all, that He neither operates by Chance, nor is confined and determined by certain necessary
Laws,

Laws, but freely, and according to his own good Pleasure, has render'd some Parts of the Body obedient to the Will of the Soul; and caus'd others to move entirely independent thereupon; nevertheless, these last as well as the first, are so far subjected to the Soul, at least related to it, that both the one and the other, so long as the Soul remains united to the Body, but no longer, are enabled to perform their Functions, and remain without Corruption.

And that Atheist that will hearken to Reason, seems particularly to be obliged to justify a Christian in the aforesaid Conclusion, since it is just those Parts that serve for the support of our Life, such as the *Heart, Stomach*, and other *Entrails* that are not only, not submitted to our Will, but moved unknown to it, by the Power of the Great Creator, that he may convince us of our Dependence upon him. Whereas, on the contrary, the Motion of such Members as the *Tongue, Hands*, and the rest, are left to the Disposition of our Will, that they may serve to Acknowledge and Glorify our Great Benefactor in our Bodies also, which is what He with so much Justice requires of us.

SECT. V. *The Imagination and Memory.*

THERE would yet have been something still wanting to the Perfection of a Humane Creature, notwithstanding this wonderful Union of the Soul and Body, if we could not have exercised the Understanding and other Faculties of our Souls upon such Objects only as are present or before us. Nor would our Judgments and Inferences or Deductions have been of much weight, if we could not have compared present Things with any other past or future.

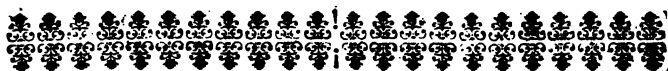
How

How should we have been able, for instance, to have made any useful Discoveries about the Laws of the Sun's Motion, in case nothing thereof were known to us besides what we could learn from things present? For as to those that are absent, such as things past or to come; the external Senses, tho' they be the first Helps of Enquiring into all Bodily Matters, cannot inform us the least thereof. Even the Hearing itself, which seems otherwise to be in some measure adapted thereto, would yet be entirely unfit and useless to this Purpose, without the other Powers, of which we are now about to Treat.

Our Gracious Creator, in order to multiply his Wonders upon us, and to render us compleatly Happy, has been pleased to supply this Defect likewise, and to lodge in us a Power of representing to the Understanding, even past, future, and all absent Things. The first of these Faculties is named by the Philosophers, the *Memory*; the last, the *Imagination*.

Whether it be now that these owe their Origin to certain Motions of the *Spirits* or *Humours*, or *Membranes*, produced by our external *Senses* or *Thoughts*, and leaving behind them Traces or Footsteps in the *Brain*, which give our Souls an occasion to think after such a manner, as if the things represented to the Imagination or Memory, were really present: Or whether there be any other cause thereof; this is certainly true, that the endowing Mankind with such a Power, does far exceed the very wisest Discoveries. And in case we were not assured thereof by Experience, who could believe that it was possible for any Man to represent to himself things having no Existence, as if they were Existing; Dead things as Living; and thus to render an Object as Present, which is either Absent, or even not Existing at all?

CON-



CONTEMPLATION XVI.

*Of the Humane Passions or Inclinations,
and briefly of Procreation.*

SECT. I. *The Passions and Inclinations.*

MAN, being thus bountifully furnished by the Goodness of his Creator with all the above-mentioned Powers and Faculties, seemed to be placed upon the highest degree of Happiness. His intelligent *Soul*, united after so wonderful a manner to his *Body*, exerts its Conceptions and Judgment upon all Matters that occur to it; his external *Senses* impart to him the Knowledge of material Beings; his *Imagination* and *Memory* represent to him every thing that is absent, either past or to come; his *Heart* and *Arteries* beat; his *Bowels*, and all his other Parts that are necessary to Life do, by the Power of his Creator, continually discharge their Functions, without giving him the least trouble during the whole Course of his Life; the other Limbs and Members are obedient to his Will, enabling him to glorify his Maker with Thankfulness, and to be useful to himself and his fellow Creatures.

Now this last might seem to be in some manner inconvenient to him, it being the only Motion that can occasion Trouble or Weariness to him. But to the End, that he should not faint nor be discouraged

couraged whilst he is promoting his own Happiness, or that of others who are dear to him; it has pleased the same Gracious GOD not only to enable all the Powers of Man to be concurring thereto, but, which is a greater and particular Benefit, to be concurring therein with Pleasure; and accordingly, to endow him with various Inclinations and Passions to stir him up to perform, with Zeal and Eagerness, all that is necessary for him to do.

Thus we find in ourselves a Desire or *Longing* and *Hope* for that Good which we consider as approaching to us; and *Joy*, when we have obtained it, and *Love* towards it, when we are possessed of it: And on the contrary, a *Fear* for approaching Evil; a *Sorrow* when it comes upon us; and *Hate* against the Causes that make it keep the Possession of us. Now, not to give a List of their Names here; Can any Man contrive or invent sharper Spurs to induce him to seek after that which he esteems good to himself, and those that are dear to him, and to avoid all that he thinks Evil? And how strongly a Man can be excited thereby, daily Experience teaches us; as well as the deplorable Examples of those unhappy Men, who by a corrupt Judgment, embracing Good for Evil, and Evil for Good, make a wrong use of these so necessary Passions.

Now to repeat our Question again, Can these Incitements and Allurements be lodged in us by mere Chance, or any thing that has neither Knowledge nor Understanding? Which, in order to render us more happy, do not only induce us to perform our Actions with so much Eagerness, but do likewise, upon many occasions, and even without our Will, give the Instruments of our Motions more Life and Energy; or, have not here all reasonable Men just cause of Thankfulness for the Mercies of their Creator, who, considering us as
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the Master-piece of. all his Works, would not suffer us to want those Powers, whereby we are enabled to promote the Welfare both of ourselves and fellow Creatures, even with Pleasure and Satisfaction.

S E C T. II. *The Difference of Passions and Inclinations.*

A N D if any one should fancy that this Question supposed too much, in order to demonstrate, that the Wisdom and Goodness of the Creator only, and no accidental or ignorant Causes have any Place in these Passions: Let him but reflect upon these two or three following things with us; from whence the Government of GOD, and the Execution of his wise Purposes, seem to shine out so brightly, that even an Infidel, or any other that doubts of it, if he would but use his Reason, cannot with any Foundation, insist upon a fuller Proof thereof.

For were there no GOD that directed every thing according to his Providence; how comes it to pass that Men whose Bodies and all the Humours thereof consist of the same Matter do yet, in cases where the Interest of Humane Society requires, differ so much from one another, in their Passions and Inclinations; insomuch, that each of 'em do with Pleasure embrace some particular Business (with a view to their own Ease and Advantage) in order to please and profit their Fellow Creatures?

Now since no Man's Life is long enough, nor no Body's Opportunity or Power great enough to provide every thing for himself necessary to his Support and well Being; can we not herein discover a Providential Direction, to render Men Assisting and Helpful to each other in their particular

lar Wants, that each one, out of Choice and Inclination, is driven on, even tho' his own Gain be chiefly in view, to concur, as far as in him lies, thereto? Thus it happens in our Fancies to particular Studies; one finds himself inclined to that of Divinity; another to the Study of Laws and Customs; a third to Physick; a fourth to an Enquiry into the Nature and Works of GOD; others, to the reading of the Transactions and Revolutions that have happen'd to the World in former Ages, in order to apply that Knowledge to the Prudent Conduct of Affairs in their own Time. Many again find themselves inclined to quite other Sorts of Employments; such as don't so much care for a Speculative Life, take more pleasure in Trades and Merchandizing, which likewise they make Choice of according to their different Passions and Humours. Others betake themselves to the several Arts of Painting, Building, and to Manufactures, of which likewise the kinds are both Different and Numerous.

Now can any one think, that it is the result of mere Chance, that Men, from all of whom, by reason of the Similitude of their Structure and Food, one should seem to expect nothing but an Identity of Inclinations, do discharge their Affairs and Functions so variously? And as strange as this may appear to every one at the first view, yet does not Experience teach us, that 'tis of absolute necessity to all Mankind that it should be thus? And in case all of them were inclined to the same thing, for instance, if every Scholar should apply himself to the same Studies, every Merchant deal in the same Wares, every Artificer in the same Handicraft, there would not only be a Failure, but likewise an entire Deprivation of the Ease and Convenience of the whole World.

Now

Now can we not see in all this, the Direction of a Supreme Governour plainly shining forth, who, to convince all Men of his Goodness and Mercy, causes them to live for the Benefit of each other, and what we cannot do for ourselves, administers by others to us; and has implanted such differing Inclinations in Humane Creatures, notwithstanding the little Difference there is in their Production, Structure and Preservation; to the end that we may more clearly perceive his Wonder-working Hand, and that we should not ascribe these so necessary Faculties of the Mind to meer Chance, or to the Ignorant Laws of Nature?

SECT. III. *The Agreement of the Inclinations and Passions.*

• AGAINST all this, a miserable Philosopher that apprehends nothing more than to be forced to acknowledge a Supreme Director of all Things, and consequently to meet with an undoubted Punishment for his Blasphemy and Atheistical Behaviour, would endeavour to object this Subterfuge and Evasion, namely, that we are taught by Experience, that such a great Difference of Passions are innate, and brought into the World with all Men; and therefore, that they only flow from the particular Contexture of Bodies, &c.

But to convince these Persons that this, and every thing besides, is rather the effect of a wise Direction, than of mere Chance or the ignorant Laws of Nature; let them go a little farther with us, and ask themselves the following Question; In case this variety of Passions does proceed only from the Structure of Men, how comes it, that the contrary has place where the diversity of Inclinations

would be hurtful to the Publick? Why have all Men living one and the same Desire to eat their Food with Pleasure? Why are all Men, and even all other Living Creatures, hurried on with the same, and sometimes, ungovernable Passions, to Generation or Procreation? And lastly; Why have they the same Love to their Children?

Certainly no Body will deny that unless these Passions were found to be alike in all Men, and in case there were room here for so great a Disagreement as in the others; or, to carry on the same Comparison, if the Desire towards Food were only found in a few Persons, Food itself would be no otherwise used by many, than as a Medicine against that Death which was to be the Consequence of an unsatisfied Hunger. Now, with how much Aversion and Loathing this happens in many, even where the Distemper renders it most necessary, is sufficiently known, and from thence as easily infer'd, that many People, abstaining too long from the use of Food, lose the Powers and Faculties of Digestion. If likewise there were as few inclinable to Generation, as we see there are who choose the same way of Living and Employments, must it not be confessed that the World would be soon Naked and Dispeopled? Again, if the Love of Parents to their Children were so uncommon, as the Inclination of Men to one and the same Trade or Calling, how many poor Creatures just born, would for want of Necessaries, meet the End of their Lives almost as soon as the Beginning?

And, to conclude the whole with one word, Let an obdurate Atheist put this Question to himself, and Answer if he can: Whether he does not therein discover the Wisdom of a Great Director? And whether he can, with an entire Conviction,
and

and without being contradicted by his own Conscience, affirm, that it appears to him to be merely accidental, that there is found a variety of Inclinations in Men, where such a variety is useful to Mankind ; and on the contrary, that the Inclinations and Passions are there only uniform where such a Uniformity is necessary ; and where a Disagreement would Dispeople and Desolate the whole Earth ? At least, let him tell us, whether, if he were to have regulated these things for the good of the World, and with the utmost Prudence, he could have fallen upon a better Method ?

S E C . IV. *The Love of our Country.*

W H A T necessity can be deduced from any natural and ignorant Cause, from whence it should follow, that all Men feel such an over-ruling Inclination towards the Country in which they are born ? And how is it possible, that the cold, barren, Northern Parts of the World, where besides, a great Part of the Winter is nothing but a dismal Darkness, should not yet be Dispeopled of their Inhabitants ; or, that they should not yet have betaken themselves to the fine Southern Countries, where the Air is milder, and all the Necessaries and Refreshments of Life more plentiful, long before now ; and, which is more, that many Men after having tasted the Pleasure of the latter, should yet freely return to the former : I say, how can this be accounted for, without resolving it into the Will of the Great Director, that Men should likewise inhabit even such Parts of the Globe ?

SECT. V. *The Contempt of Dangers.*

IF this be not sufficient to convince our Atheist, let him consider in the last Place, whether he can, upon his Principles, account for that dreadful Thirst after Honour and Glory, which all Ages have beheld with Amazement, in the Actions of their Heroes; and which hurries Men on, and makes them run headlong into the greatest Dangers, yea, even Death itself, to which Humane Nature has the greatest Aversion.

Not to mention those whom their Wants oblige to follow the War, can any one reflect, without wondering, that Great Men and Illustrious Persons (who are otherwise in a Condition to enjoy all the Pleasure of the World in Plenty, and at least, to die an ealie Death in a good old Age) should yet expose themselves with so much Zeal and Bravery to the innumerable Dangers of War, where they daily, and by a terrible Experience, find that Lot to fall to others, which to Morrow, or perhaps sooner, may be theirs; also of being slain, or at least render'd miserable all the rest of their Lives, by their Wounds and Loss of their Limbs?

If now it should be answer'd that the Generous Thirst after Honour subdues and stifles all the contrary Motions in their Souls, yet even this proves a Supreme Direction, which, by fixing these Noble Sentiments in such great Subjects, brings about its own wise Ends and Purposes. But forasmuch as this Passion, how strongly soever it affects those brave Heroes, is in itself entirely inept thereto (for no Body can flatter himself that all these Efforts to get Honour shall insure him against a Cannon-Butler, or any other fatal Wounds;) and as much as they value the Praise of Courage and Bravery, yet Dying is Dying, and consequently a thing to
be

be feared in itself; and certainly as high as the Glory of Arms may be extolled, after Death, they can reap no Pleasure from it, the rather since they can not be ignorant that the Honour which Men get by dying in the Field seldom accompanies any but such as have been great Generals; whilst others who have not attain'd to so high a Degree, altho' Brave and Valiant in their Lives, are involv'd in an utter oblivion as soon as dead, their Name and Fame being bury'd in the same Grave with their Bodies, whilst none but their Friends or their desolate Widows and Orphans lament their sudden and immature End.

But notwithstanding all this, we see many, and such as have but a small share in the acquir'd Honour of a Victory, in case they fall and dye in the same, and who might otherwise have spent their Lives with Ease and Pleasure, abandon themselves to the Perils of War.

Now, to ascribe the Cause of such a noble Courage and Bravery to meer Chance, is a very ungrateful and unworthy Treatment of those great Men, whose Wisdom has not given the World less matter of Admiration, than their Courage.

To deduce it from stronger Passions, is likewise not possible, as we have already shown, because the fear of Death, provided that they may live without Shame or Misery, is the strongest of Passions in all Men whatsoever. What Reason then can be thought of for all this, save only the Supreme Will of the great Director of all things? who has infused into the Souls of some Men, whom his Providence has marked out for great Events, the right Principles of a true Generosity and Courage; letting them see that he has chose them out of an infinite number of other Persons, and laid this Obligation upon them of opposing Tyranny

and absolute Power, and of restoring to their own Country, and to their Friends and Allies, those dearest Blessings of Religion and Liberty, even at the hazard of their own Lives. And who again has made others, tho' they proposed to themselves no other End than the gratifying their own Inclinations, or 'at least, acquiring Riches and Glory, like many of the Heathens, to despise Death and Danger in a most unconceivable manner; whereby he has compelled them, tho' insensible thereof, to be subservient to his Providence and Adorable Purposes.

SECT. VI. *Convictions from the foregoing Observations.*

LET him that has hitherto doubted of God's Government, seriously reflect upon this Great Wonder, and see whether he can deduce that which he finds true by Experience, of the Course of these Passions and Inclinations in Mankind, from an accidental Concurrence of *Nerves* or *Fibres*, or *Humours* of the *Body*; or from any Laws of a stupid Nature, unable to propose to itself the least Design in all its Works; And then tell us how it can come to pass, that upon such Principles, these Functions so necessary and useful to humane Kind, and at the same time so wonderful too, can be so constantly discharged; and that in all Ages the same Steadiness and Uniformity has appeared therein, which can never be applied or attributed to meer Chance?

SECT. VII. *The Desire of Procreation.*

CAN any Body avoid seeing from all that has been said, that the Inclinations inherent in Mens Minds, as corrupt as they be, and applied often to wrong Objects, owe their Origin to something more than Humane Wisdom? Which, having thought fit to render them subservient to his great Purposes, causes them to prevail over all Obstructions; to which end, he has vouchsafed to qualify the most Bitter Things, which in their own Nature can produce nothing but Aversion and Terror, with the most desirable Charms, and to render them, as I may say, Palatable, with an agreeable Sauce to incline our Passions thereto, notwithstanding all the aforesaid Impediments; and to the end, that we may put this past all doubt, let the Atheist, besides what we have just now said, about the Contempt of Dangers; let him, I say, turn his Eyes with us upon that Inclination which Men feel in themselves towards Procreation.

Now if it were not the Will of the great Director of all Things, that the Race of Men, which would otherwise end in each Individual, and be quite extinct with the Life of one Man only, should be supported in their Posterity; How happens it that all Living Creatures are hurried thereto with a Passion exceeding all others? But to proceed farther, How is it conceivable, when in the bearing and bringing forth of Children, Women do not only undergo so much Trouble and Pain, but frequently visible Danger of Death, that there should be one only to be found, that would venture the same a second time after once having made the terrible Experiment? I say, how comes all this to pass, if it had not pleased the great Creator to

confirm the Words which he spoke in the beginning of the World, *Gen. i. 28. Be fruitful, and multiply, and replenish the Earth.* And thus to support the Truth of them by a never-failing Experience. In vain do we seek for other Reasons thereof, nor can any thing seem more unreasonable than to ascribe this to Chance or Ignorant Causes, especially if we weigh the following Circumstances: Can any one imagin, that it is without Design, that there should be made just two sorts of Persons in every thing alike to each other, and different only in those Parts that are required for Generation; and that, besides these two, we know well enough, that there was never any third?

SECT. VIII. *Why we have not treated more fully and minutely upon the Business of Generation.*

WHOEVER reads this will perhaps think it strange that we have not spoken more largely concerning the Affair of Procreation, since the Providence, Wisdom and Power of the great Creator shines forth so irresistibly and glaringly in that whole Matter. But they may be pleased to know, that the same Reasons that made us keep silence, or speak sparingly upon many other of the foregoing Subjects, such as the manner after which the Separation of the Humours is made, the Tumefaction or swelling of the Muscles, the Uses of the external Senses, the Limits of the so called *Sensorium Commune*, and many more, have induced us likewise to observe the same Caution here; *viz.* because the Truth has not yet been confirmed by Experiments in so sure a manner, but that there still remain a great Variety and Difference in Opinions among the most learned Men concerning them.

SECT. IX. *The Principles or Stamina of Living Creatures.*

WHETHER it be then, that the first Principle, or *Stamen*, of Men are to be sought for among the *Animalcula*, or among other Particles without Life indeed, but put into Motion (for thus differently are they defined by some of the most famous Enquirers into Nature) which, by the help of Microscopes are discover'd in *Semine Masculino*, of all Creatures that have been hitherto examined: Whether it be to be found in the Eggs of the Females, as others pretend; or lastly, whether it be that the Coition of both the Sexes is necessarily required to the Formation of this *Stamen*; all which we do not pretend to determine here: This is however sure enough, and after so many Enquiries, is received by all the Modern Philosophers, that all Living Creatures whatever proceed from a *Stamen* or Principle, in which the Limbs and Members of the Body are folded and wound up as it were in a Ball of Thread; which, by the Operation of Adventitious Matter and Humours, are fill'd up and unfolded, till the Structure of all the Parts have the Magnitude of a full-grown Body. In order to be convinced thereof, the Reader may consult the Observations of the great *Harvey*, both upon Men and Beasts, both the *Viviparous*, or such as bring forth their Young alive, and the *Oviparous*, or those that lay Eggs; in his Book *de Generatione Animalium*. And after him the accurate *Malpighi*, in the Experiments he makes upon the Hatching of an Egg, and the Formation of a Chicken in the Egg.

Thus we find the first of those speaking of it in his 15th Exercitation; *That the Stamen, to the best of his Knowledge, before he had observed it, was accounted by no Body to be the first Origin of the Chicken.*
And

And *Malpighi* speaks of it in the following manner: *Wherefore it must be owned that the Stamen of a Chicken is already in the Egg before the Hatching: and therefore must have proceeded from a Higher Cause after the same manner, as in the Eggs of Plants.* Thus he makes an entire Analogy between the *Stamina* of Living Creatures and the Seeds of Plants: In which last he is likewise wont, for the same Reason, to mention some Parts by the Name of the *Uterus*, *Placenta*, and the like, which are only proper to Living Creatures.

It shall suffice here, to have quoted those two great Men for the Confirmation of the Truth of what has been before-mention'd, since they seem to have been the first Discoverers thereof: And since all the Great Naturalists of this Age have been convinced thereby, and by their own further Experiments, that the Beginning of all Creatures consists in a *Stamen*, as may be shewn in numberless Places of their Writings, which those that please may have recourse to.

I would have been something more particular upon this Subject here, which seems to be the proper Place for handling it: But forasmuch as the encrease and growth of Animals from these little *Stamina*, may receive a great Light from those of Plants, which may be found in every Seed; I chuse rather to refer my Reader to *Contemplation XXIII.* where I expressly treat of that Subject; or rather to the *Observations upon Plants*, of those famous Philosophers *Messieurs Grew* and *Malpighi*, where he may find Experiments enough, to shew that a Plant is produced from a *Stamen*, and a living Creature from a like *Stamen*; or, to speak in their usual Language, is unfolded, as we see in a Silk-worm, where the Butterfly comes out of the *Aurelia*, in which all the Parts of the Butterfly are involved or roll'd up. See *Malpighi de Bombyce.*

And

And since we have already an Experimental Certainty, that a Male and Female Creature are necessary toward the Procreation of another of the like Species; I leave it to those that have the Opportunity of carrying their Enquiries farther, what is performed by each of 'em in particular, towards Generation; as likewise, whether in the Egg of a Female, the solid Parts of the *Stamen* of the future Creature are to be found; and whether it be impregnated and vivified by the *Semen Masculinum*, and brought into Motion agreeable to the Laws of the Seminal Matter.

This seems to have acquired some degree of Probability; forasmuch as we know that the Body of a Man does not only consist of Solid and Fluid Parts, but is likewise endowed with certain Laws, pursuant to which all the Parts are moved; so that thereby the same Bread, which at first according to the Laws to which 'twas Subject in the Plant, was Wheat or Rye, being afterwards eaten by a Pullet, does, according to other Laws, become Pullets Flesh, and finally this Pullet being again Converted into Humane Food, becomes the Flesh of a Man: and so in other Cases.

This might cause some Suspensions, whether that which is discover'd by the help of a Microscope in *Semine Masculino* (which the accurate *Verbeyn*, *Part II. p. 69.* asserts to be Particles put in Motion, and not the *Stamina* of Living Creatures) may not be that Matter, which, according to the Laws that the great Creator of all Things has produced in every particular Man and Beast, being put into Motion (and like Fire that kindles other Matters, or Yeast that ferments other Liquors, and moves them according to its own Laws) does propagate and maintain the Laws of the required Motions in other Substances: Whereupon the Observation of *Mr. Hartsoeker*, as related by the said *Verbeyn*, are very

very remarkable; it appearing thereby, that this mov'd Matter in *Semine Masculino*, does preserve its Motion some Hours in the Cold, but in the Heat it soon disappears. This seems better to agree with Particles that evaporate with Warmth, than with *Animalcula*, which usually stand in need of it, and are first produced by Warmth; at least, if we suppose these Particles to be divested of Animal Life, and to be only Matter put into Motion, this absurd Consequence may be prevented, namely, that in the *Semine Masculino* of every Creature, there must be a Thousand lost for one that comes to good.

Experience does likewise seem to confirm the said Hypothesis (that from the Female proceeds the Matter, and from the Male the Particles that propagate the Laws of Motion therein) soasmuch as a Mule is produced from the Coition of a Horse and an Ass; and so in other Mixtures of different Species. The above-mention'd Mr. *Verheyen*, p. 71. may be consulted hereupon. But this may suffice for Probabilities, since, as far as I know, no Body has yet been able to give us an entire Decision of this Matter.

SECT. X. *Convictions from the foregoing Observations.*

ONLY soasmuch as it is now found to be experimentally true in almost all kinds of Plants and Living Creatures, that have been enquired into, that the former have their Origin in a Seed, and the latter in *Stamina*; but none from meer accidental Causes, as Corruption and the like, I cannot upon this occasion forbear entreating the unhappy Atheist, if any Convictions will yet satisfy him, that he would be pleased seriously to reflect on all these things by himself, and then pronounce, whether mere Chance, or other Causes ignorant

norant of what they did, when they thus acted, could produce all these *Stamina* of Men (not to mention here the Seeds of Plants and Eggs of other Creatures) with so much Art and in so great a Number; and could insert and fold up all the Limbs and Joints of such a wonderful Machine, as is the Humane Body, in so nice and accurate a manner, that the same should be fill'd up and nourished by Juices, or (to use the common Technical Word) having expanded or unfolded it, would bring this Body into such a Disposition and Structure as is necessary for so many great Purposes for which it is formed.

The Atheist cannot be ignorant how many Learned Men have openly acknowledged in their Writings, the Almighty Power of the great Creator, upon enquiring into these his wonderful Works and Productions of Men, Beasts and Plants from such seeming inconsiderable and contemptible *Stamina*. Now then one of these two things must be true; either that it is a certain and undeniable Demonstration of a G O D; or that so many famous Men, are utterly ignorant wherein the Strength of such a Proof consists, and are therefore to be accounted compleat *Visionaries*, if not mere Fools. This last must be asserted by the Atheist concerning most of the famous Undertakings of the late Age, or else he must abandon his unhappy Principles: Let him therefore consider with himself, for what he himself must pass, with all Rational and Equitable Persons.

S E C T. XI. *Several Difficulties removed.*

N O W that a *Stamen*, which perhaps at first contained nothing more than the Quantity of a little Grain of Sand, and perhaps less, can be unfolded or expanded to the Magnitude of a Humane Body
of

of Six Foot long, a Mathematician will freely, and even an Atheist himself, if he understands any Thing of the Mathematicks, must confess. But forasmuch as others, and even some well-meaning Christians, cannot easily conceive this great Expansion of such a small *Stamen*, and may therefore think it impossible, it seems proper and useful too, to remove this Difficulty, by shewing the possibility thereof.

Let it therefore be supposed ;

I. That the Divine Power can divide a determinate Quantity of Matter (for instance, a little Grain of Sand, or any Thing less) into so many Parts, and more than any Man can express by a definite Number. No Body can deny this ; and even an Atheist must acknowledge, that in respect to this Grain of Sand, such a Division or Separation of Parts does neither include a Contradiction, nor any Impossibility in itself.

II. That a Foot being divided into ten Parts, each of those Parts may contain a Hundred Grains of Sand ; which many other do admit with us.

III. That the Body of a Man which is Six Foot high, may be supposed to contain in it Six Cubical Feet ; which, allowing for the Cavities therein, may be a pretty just Calculation.

IV. Now since 100 Sands do compose the tenth Part of a Foot in length, which we will here call an Inch, and there are ten such Inches in a Foot, a Thousand Sands will go to the length of one Foot ; and consequently (supposing for convenience-sake, the Sands to be so many little Cubes 1,000,000,000 or (to express this Number with more Brevity, or the Unite with nine Cyphers) 10^9 Sands do compose one Cubical Foot, which being multiplied by Six, makes the whole number of Sands, that may be contained in a Humane Body
of

of Six Foot in length, amount to 6,000,000,000, or 60^9 ; from whence it appears, that in case such a Stamen, no bigger than a small Grain of Sand, were divided into 6,000,000,000, of Parts, one Particle of the said Sand might be placed in each space of a Sand in that Body.

V. Now to proceed further, since it appears from the XXVI. *Contemplation*, §. 16. of Mr. *Leuwenboeck*, that $\frac{1}{1000}$ of the length of a Sand, is the utmost that can be distinguished by a Microscope; to the end, that we may not take any Quantity that may be justly suspected of not being distinctly visible; let us take the $\frac{1}{1000}$ of this length; so then $\frac{1}{1000000}$ of a Sand's length is incapable of being distinctly viewed by any Microscope. Since then there go 10^{12} of such Particles into the Composition of one Sand, there will be 6027 of such little Cubical Spaces in a Humane Body of Six Foot in length; but by reason of their Smallness, they will be undistinguishable, even with the best Microscopes.

Now if we suppose that in each of these small Spaces, there be a Million of Parts in one Sand, there will go to the Composition of the afore-mentioned Body 60^{33} of the like Particles of Sand.

VI. Now in case the *Stamen* of a Man, which we have supposed to be as big as a single Grain of Sand, were divided into so many, or into 60^{33} Parts; its Parts may be so disposed and expanded, that in each small Space of a Humane Body of Six Foot in length (which Parts, by reason of their Smallness, have not yet been able to be distinguished by the finest Microscope) there may be contained a Million of such Particles of Sand. And since the Interstices between the Particles of the *Stamen* are yet so much smaller than the afore-said little Spaces, they will be yet less visible thro' a Microscope, and consequently almost invisible to the naked Eye; certainly in no manner distinguishable.

VII. And

VII. And thus it appears to be possible, that such a small *Stamen*, no bigger than a Sand, may be expanded and brought to the Analogous Composition of a Humane Body of Six Foot long ; which Body, in its whole Matter, did not contain more than the quantity of this single Sand, yet in such a manner, that there was not one visible Place therein so small, in which there were not contained more than a Million of Particles of this little *Stamen* : Between all which Particles, there were still remaining so many Interstices or Vacuities, that this Body, which, by reason of its Lightness, might be deemed little more than a Shadow, can be so filled with flowing and adventitious Parts fixing themselves in these Interstices, and Cloathing as it were the Parts of this *Stamen*, that it at last attains to the Weight and Size of a Common Body of a full grown Man.

VIII. And to the end, that no one may be surprised at these minute Divisions of the quantity of a Grain of Sand, he will find in *Professor Keil's Introduction*, p. 55. something that may appear much more wonderful to him, of which however, the Possibility is there demonstrated ; *viz.* How not only a Body of Six Foot in length, but even that immeasurable Space, containing in its Circumference the Starry Heavens ; or even a much larger, if you please, may be filled and obscured by the Dust of one single Grain of Sand, after such a manner, that not so much as a Ray of Light, tho' never so fine, shall be able to pass between the Parts of that Sand : Imagine then how far this surpasses all that we have supposed to happen in a Humane Body.

IX. To prove this by a like Experiment, we shall show in our CONTEMPLATION upon *Light*, that a Particle of the Tallow of a Candle, not exceeding the quantity of a single Grain of Sand, is really and actually divided into many more than the aforesaid 60th Parts.

To

To demonstrate this very briefly here, you will find in the just now mention'd Contemplation, that a Cubical Inch of Candle-Tallow, does emit or yield the Number of 269617040^{40} Parts of Light. Now, according to *Numb. IV.* here above, there are 1000,000 Sands in the quantity of such a Cubical Inch, and consequently there proceed from a Particle of Tallow, of the bigness of one Sand, 269617040^{34} Parts of Light.

And according to *Numb. VI.* the Stamen that was likewise of the size of a Sand, was supposed to be divided into 60^{33} Parts.

By which number of the like Particles, which proceed from the quantity of a Sand, or are divided into 269617040^{34} Parts, there will proceed 44936173 with a little Fraction. From whence it appears, that each little Particle of this Stamen, how small soever it may be (to take a round number) may be still divided into 44; and very near 45 Millions of Parts; before each of them arrive to the Smallness of one of the Particles of Light, that continually flows from a Burning-Candle.

Now that these exceeding small Particles are not unnecessary, on account of their Smallness, but are made use of to great Purposes in the Universe, shall be hereafter Demonstrated in our 25th *Contemplation*; as it is manifest from those of Fire, which are found every where in the visible World, and are made use of by the great Governour thereof, for such wonderful as well as terrible Ends.

And thus will it appear plain enough, as I think, that in such Expansion and Division of this *Stamen*, we do not come near to that minuteness, into which we see experimentally that other Bodies in the World may be divided.

SECT. XII. *Convictions from the foregoing Observations.*

WE do not here pretend to determine the manner that GOD has been pleased to make use of in the Expansion of his Created *Stamina*; we must leave that to his infinite Wisdom, whose Ways, herein especially, are inscrutable, or past finding out; nor have we had any other view in what we have said concerning it in the foregoing *Section*, than to convince the Atheists, that they had a Maker, and to set Things in a somewhat clearer Light before the Eyes of such Christians that are not just accusom'd to compute these Matters after the manner of Mathematical Propositions; and therefore might find some Difficulty in expanding such a Small *Stamen* to the similar State of a full grown Body.

Let then an unhappy Philosopher, who will not yet confess an All-ruling GOD, from what has been said before; Let him, I say, retire to some solitary Place, and seriously contemplate his own Body, and then judge, whether it could possibly come to pass without a wise Direction, that from so small and tender a *Stamen*, expanded, filled, or stuffed out and cloathed with other Matter, a Body so wonderfully formed and adapted to so many Uses in all the Limbs and Parts, has been produced. What is there in a Watch, and in the adjusting of all its Wheels, Springs, &c. that can be compared to the wonderful Formation of a Humane Body? And yet, was ever any Man so Senseless, or, to speak in softer Terms, so deplorably Unhappy, that he should dare to maintain, in the presence of understanding Persons, that the Watch which he carries in his Pocket was framed in that manner, without any Wisdom or Design?

SECT. XIII. *Transition to a Demonstration against Chance.*

BUT as little as we know touching the manner of the Production of Humane kind; yet in what we daily see thereof (tho' scarce observed by any) there is a very remarkable and strong Proof of a Divine Providence, adapting all Things to its wise Purposes, and a plain Demonstration, that the World is by no means governed by Chance.

Before I propose it, I find myself obliged to acquaint my Reader, that the Discovery thereof is owing to the Ingenuity of Dr. *Arbuthnot*, a famous Mathematician, Member of the Royal Society, and Physician in Ordinary to the late Queen of *England*, who has been so kind as to transmit it to me thro' the Hands of Mr. *Burnet*, the worthy Son of the late Bishop of *Salisbury*, so famous and so well known to the Learned World; the which Mr. *Burnet* is likewise himself a great Mathematician, and Fellow of the said Society, and has allowed me the Honour to adorn this Treatise therewith.

S E C T. XIV. A Table of the Number of Males and Females Christen'd yearly in London in 82 Years.

Ann.	Males.	Females.	Ann.	Males.	Females.
1629	5218	4683	1670	6278	7214
30	4858	4457	71	6449	5719
31	4422	4102	72	6443	6061
32	4994	4590	73	6073	6120
33	5158	4839	74	6113	5821
34	5035	4820	75	6058	5738
35	5106	4928	76	6552	5717
36	4917	4605	77	6423	5847
37	4703	4457	78	6568	6203
38	5359	4952	79	6247	6033
39	5366	4784	80	6548	6041
40	5518	5332	81	6822	6299
41	5470	5200	82	6909	6533
42	5460	4910	83	7577	6744
43	4753	4617	84	7575	7158
44	4107	3997	85	7484	7127
45	4047	3319	86	7575	7246
46	3768	3395	87	7737	7119
47	3796	3536	88	7487	7101
48	3563	3181	89	7604	7167
49	3079	2746	90	7909	7302
50	2890	2722	91	7662	7392
51	3231	2840	92	7602	7316
52	3220	2908	93	7676	7483
53	3196	2959	94	6985	6647
54	3441	3179	95	7263	6713
55	3655	3349	96	7632	7229
56	3668	3382	97	8062	7767
57	3396	3289	98	8426	7626
58	3157	3018	99	7911	7452
59	3209	2781	1700	7578	7061
60	3724	3247	1	8102	7514
61	4748	4107	2	8031	7656
62	5216	4803	3	7765	7683
63	5411	4881	4	6113	5738
64	6041	5681	5	8366	7779
65	5114	4858	6	7952	7417
66	4678	4319	7	8379	7687
67	5616	5322	9	8239	7623
68	6073	5560	8	7840	7380
69	6506	5829	10	7640	7288

In this Table it is remarkable :

I. That at *London*, in these 82 following Years, the number of Males has exceeded that of Females every Year.

II. That the Difference thereof has always lain between 2 Terms, nor far from one another. So that,

III. There were always more Males born than the half Children amounted to in one Year. And,

IV. That the Number of the Males never exceeded that of the Females so far, that almost all the Children should be Males.

SECT. XV. *A Judgment upon the said Table.*

NOW, forasmuch as by Sea and Land-Fights, by other dangerous Occasions, and especially by a more irregular way of Life among the *Men*, a much greater number of them do daily Perish than of the *Women*, by such Distempers as are peculiar to them; can it be thought that it happens without a particular Direction of Providence, that there are constantly more *Men* born than *Women*?

And (which is wonderful) that there are just so many more, that there still remains for every *Woman* a *Man* of her own Age, in her own Country, and of equal Condition to her; This is confirmed by a perpetual Experience, to the Satisfaction of every one that makes use of his Reason.

From whence Dr. *Arbutnot* observes, it seems a plain Consequence, that *Poligamy*, or the marrying of more Wives than one, is as opposite to Nature, to the Government of the World, and the common Interest of Mankind, as it is contrary to the particular Laws of every Country; because if one Man has several Wives, so many other Men must remain without them; besides that it should seem that many Women cannot be so well impregnated by one, as each Woman by her own Husband.

SECT. XVI. *The first Mathematical Demonstration that the World is not governed by Chance.*

BUT to come finally to the chiefest Proof that may be drawn from hence, against an Accidental Cause; since Dr. *Arbutnot*'s Business would not allow him to follow this Table in all its Particulars, and from thence to form a Calculation (which, according to the common manner, would have required the continual Labour of several Months, as is well known to those that are vers'd in the Computation of the Games of *Chance* or *Hazard*) he therefore supposes for Convenience-sake:

I. That if an equal number of Pieces of Money were thrown up into the Air, the Chance of their falling *Cross* or *Pile*, as it is commonly called, would be equal; so likewise among any equal number of so many Children, there would be just as many *Males* as *Females* born in the World, if those Births happen'd by meer Chance.

II. This Gentleman shews, that if a Person (whom we shall call *A*) should have laid the Wager *D*, that in tossing up some thousand pieces of Money, there would have fallen as many *Cross* as *Pile*, the said *A* would have had a very small Chance of winning his Wager *D*; and that the value of his Chance would have been much less than $\frac{1}{2}$ of *D*.

III. But because the former Supposition, that the Number of *Males* and *Females* is yearly equal, does too much lessen the Chance of *A*, that lays such a Wager; Dr. *Arbutnot* does again advance that in order to make good such Diminution, the Chance of *A* (which is otherwise shewn to be of much less value than $\frac{1}{2}$ the Wager of *D*, every Year, or every Time) is now really so much greater, and its value is completely $\frac{1}{2}$ of *D*.

IV. This

IV. This being now laid down, if a Person (whose Chance is $\frac{1}{2}$ of *D*) should wager that such a thing should happen 82 times to one; or rather, that there should be as many *Females* as *Males* born every Year for 82 Years together; as he had wager'd before, that there should be so in one Year; they who understand the Computations of Hazard or Chance, know that this Chance will be as $\frac{1}{2}$ eighty-two times multiplied into itself, and afterwards with *D*; or that there is so great a Number (as is required when the double Number of 82 times multiplied by itself, and the Unit subtracted from it) against One that the same should not come to pass by Chance after this manner, 82 times together: Which therefore makes a Number of 25 Numerical Figures following each other, the first five whereof are 48357; as may be proved by the Logarithms with very little trouble. They that would know it more exactly, may compute it farther by the said Logarithms; or else multiply the double Number 82 times by itself, and subtract the Unit.

Now in case it is so many against one, that this should not happen in *London* 82 Years together; let any one experienc'd in Calculations consider, how great a number there will be against one, that the same thing don't happen throughout the whole World, and so often in 82 Years following; and then let him judge, whether it can be believed that Chance has any place here: For that this has really happen'd many Ages together, and in all Places of the World, may be maintained with great Probability, because, that in all Times, and in all Places, the *Men* are expos'd to more Dangers than the *Women*; and nevertheless there will be found in all Countries *Men* for *Women*, and *Women* for *Men*, of equal Age and Condition.

SECT. XVII. *The Difficulties and Objections that some may make against these Calculations answer'd.*

THUS far Dr. *Arbutnot*, whose brief Remarks upon what has happen'd, according to this Table, is so strong a Proof of a wise Government of the World, that the same ought fully to satisfy every one who understands this Calculation. But since some Atheists, willing to evade the Force of this Argument, might start the following Objection; That Dr. *Arbutnot*, to avoid trouble, supposes the Chance of one who lays a Wager, that such a thing should happen in one Year to be as $\frac{1}{2} D$; and that it does not agree just literally with the Table; let them know, that the sole Mistake that can be said to be made therein, is only this; That this Gentleman allows too much to those that assert a Chance in these Matters, by supposing the Odds to be $\frac{1}{2} D$; and that therefore the Number, that according to his Hypothesis stands against One, is much smaller than would be produced upon these Grounds by a more accurate Computation; in case he could have allowed the necessary time for making it. This is obvious to all that understand this Computation, since, allowing his Adversary the half of the Chances, he will win if there be only more Pieces of Money falling Cross or Pile, or more Males than Females born, without any Limitation, when the Number of the Pieces, or of the Children is unequal; and in an equal number of Pieces, or of Children, the Adversary would over and above have for himself the half of all those Chances which an equal Number of Cross and Pile, or an equal Number of Males and Females, should give: Whereas, according to the Table (by reason of the Limitations, between which the Majority of Males is really found) a great many Chances, in which there are more
Males

Males than Females, would make them lose; as also all the Chances which an equal Number of both would produce: Which does not want to be Demonstrated for such as are only experienced in the beginning of these Calculations. I thought it my Duty to add this, in order to clear the said Calculation, which indeed is strong enough, but was however framed with a Design of not spending too much Time upon it, from all the Objections of such as pretend to cavil at it.

And all that we have here said, viz. that Dr. *Arbutnot*, to avoid the Trouble and Time that so nice a Calculation would have required, has granted his Adversaries much more than was necessary; may visibly appear from the Calculation which that most ingenious Mathematician Mr. *'Sgravefande* (Professor of Mathematicks at *Leyden*) has been pleas'd, after a particular manner, to make upon it; by which the usual Method necessarily required in the Discussion of this Matter, and in which a vast deal of Pains and Time is taken up, is extremely abridged.

SECT. XVIII. *A second, and more accurate Mathematical Demonstration, that the World is not govern'd by Chance.*

THIS Gentleman therefore resolving not to confine himself to any particular Hypothesis, and with a closer view to the Numbers of the Table itself, in order to discover that Number standing against One, that what happen'd in *London* in the above-mention'd 82 Years, would not have happen'd, if it had been the meer result of Fortuitious Causes, adds up all the Children born in those 82 Years, in one Sum together, and finds that the 82d Part thereof amounts to 11429; which Number is therefore the Medium or Middle Number, which,

which, in case there were so many born yearly, would again produce in 82 Years the same Number of Children as the Table contains in its Total.

Finding moreover in the Table, that in the Year 1703, the Difference between Males and Females, in proportion to the Number of Children, was the smallest; and that in the said Year there were but 15448 born in all, of which 7765 were Males, and 7683 Females, he takes the middle Number to be 11429; and according to this Calculation he supposes there to be 5745 Males, and 5684 Females.

In like manner observing, that in the Year 1661 the Difference between Males and Females was greatest, if calculated again according to the afore-said middle Number 11429; the Males of that Year will come out 6128, and the Females 5301.

The first Question then which is here to be answer'd, may be propos'd after the following Manner:

A wagers with *B*, that if 11429 Pieces of Money be thrown up in the Air, there will not fall down of 'em fewer than 5745 Crosses, nor more than 6128 Pile: or thus; that among 11429 Children, born every Year according to this Medium, there will not be fewer Males than 5745, nor more Females than 6128.

The Question then is, concerning the value of the Chance of *A*? or rather, how many Chances there be against One, that what *A* has wager'd shall not come to pass, if all things depend on Fortune?

SECT. XIX. *The Calculation after the common Manner.*

To return an Answer to this Question, let it be supposed that C signifies Cross, and P Pile, or Males and Females, then they who understand the Modern Calculation of the Games of Hazard, know,

I. That the *Binome* CP, or MF, must be raised to the Power of which the *Exponent* is 11429, or the said Sum of 11429 must be multiply'd by itself.

II. That all the *Co-efficients* or *Genitures* of the Terms taken together, or the Power of the two Numbers, whereof 11429 is the *Exponent*, yield the quantity of all the Chances that can happen concerning the said 11429 Pieces of Money. We will call the same $p + q$.

III. That all the *Co-efficients* as well of both the Terms, in which we find $k^{6128} m^{5301}$, and $k^{7745} m^{3684}$, as of all the Terms that are between these two, being added up together, make up the number of all the Chances which will cause A to win. We will call it p .

IV. That all the other possible Chances, except those which cause A to win, are to the Advantage of B, and these we will call q .

V. Wherefore if D be put in, that the value of the Chance of A, is $\frac{p}{p + q} D$, when A has wager'd or laid that it shall happen once, in the Money thrown up, or with the Children in one Year.

VI. and therefore the Chance of the Wager laid by A, that it shall so happen, against that of B, who has laid the contrary (supposing it all meer Hazard) is as p^{12} to $p \mp q^{82} - p^{82}$, or, to make use of the Unit, according as it is exprest in the former Question;

Question; as 1 to $\frac{p+q^{82}}{p^{82}} - 1$, that is, as the Unit,

to a Number which is found by dividing the quantity of all the possible Chances $p+q$ by p ; or by the quantity of all those that cause A to win, and subtracting the Unit from this Quotient multiply'd 82 times by itself.

SECT. XX. *This Tedious Calculation Contracted.*

ALL this, as we have said above, is well known to such as are vers'd in the Computations of the Chances of Games, but it is however very certain, that as short and easie as the Solution of this Question appears to be in Words and Algebraical Letters, yet the nimblest Arithmetician, considering the greatness of the Numbers that are to be found, would want some Months to dispatch it, if he would express it properly by Numbers, and would also be satisfied, that there were no Mistakes in his Calculation. Wherefore the aforementioned Mr. *Sgravesande*, according to his vast Experience and Skill in Mathematics, has remarkably abridged this Matter, and cut off the much larger Part of the tedious Work, which the common Method naturally requires, shewing demonstratively, and with incomparably less Pains, that the *Ratio* of the Chance of A to that of B , found

in the foregoing *Section*, as 1 to $\frac{p+q^{82}}{p^{82}} - 1$ (not on-

ly with the requisite Exactness, but even the causing several very small Fractions, which would otherwise have been neglected, to tend to the Advantage of A , and thereby not to be liable to any Contradiction) I say, that the said *Ratio* may be express'd by the *Ratio* of the Unit to a Number, which results or is found by the multiplying $\frac{1}{3} \frac{2}{4} \frac{4}{7} \frac{8}{9}$ eighty two times by each other, and subtracting the Unit.

Unit. So that with very little trouble, and by the help of *Logarithms*, we may see that there is a Chance of 44 Figures (of which the first five are 75598) against One, that what happen'd in *London* in the said 82 Years, would not have happen'd, if it had been directed by Hazard only.

Mr. 'Sgravefande, who has computed the same by Logarithmical Tables, finds it to be, 75, 598, 215, 229, 552, 469, 135, 802, 469, 135, 802, 469, 469, 135, 802, 469, against One.

SECT. XXI. *Convictions from the foregoing Calculations.*

NOW let every Man that can represent to himself the greatness of this Number, judge whether it is a wise Direction, or Fortune and Hazard only, that take place in this Matter; the rather, if he considers how much greater this Number or Sum would be, if the same Thing happen not only at *London*, but throughout the whole World, which, for the Reasons already alledg'd, is very probable.

This is certain; that since this Sum is greater than all the Grains of Sand, which some Millions of Globes, like that of the Earth, can contain, he that thinks it credible that what happen'd at *London* fell out by pure Chance, must likewise maintain, that he thinks it as probable, that a Person deprived of his Sight and Feeling, and who has no manner of Rule for the Direction of his Hand, and therefore must abandon himself entirely to Chance, should single one particular Grain of Sand out of such an unconceivable Heap jumbled all together, the very first time he should put his Hand into it.

Now tho' Mr. 'Sgravefande has done me the Honour to send me not only the proper Demonstrations, but likewise several and different ones after

an uncommon manner; yet I have past them by here; first, because they who are anywise vers'd in these kinds of Calculations, may find the common Manner briefly represented above; but if they don't understand 'em, the Demonstrations that are subjoin'd will not be able to give them any Light; and yet this Discourse would be swell'd thereby to too great a Bulk: And, Secondly, because that learned Gentleman's Method of Demonstrating and of Abridging, will shortly be publish'd with other of his Works, of which they who have Inclination and Ability may make a just use.

In the mean while every one may from thence deduce a Proof of what has been advanc'd already, to put the Method used by Dr. *Arbutnot* beyond Contradiction.

SECT. XXII. *Expression of the Number found in Common Words.*

BEFORE I quit this Subject, since there be among these Philosophers who ascribe all things to meer Chance, some also that are not used to extend their Speculations to Arithmetic, or Numbers, and to whom the common Expressions of *Billions*, *Trillions*, and the like are unintelligible, and consequently make no Impression on them; it may not perhaps be unprofitable, in order to give them a more convincing Conception of the Number discover'd by Mr. *'Sgrave*, *§. XIX.* to express the Greatness thereof in such Words as every Body understands.

For which Purpose we know that when this Number of 54 Figures is divided by the Unit with 39 Noughts or Cyphers following (*§. XIX.*) there will remain a Dividend of 75598, and a Fraction besides. From whence it follows, that if we multiply a Number of *a Hundred Thousand times a Hundred Thousand Millions,*

Millions, first with a *Hundred Thousand times a Hundred Millions*, we must take *Ten Millions* of this prodigious Number above *Seventy five Thousand, five Hundred and twenty eight times*, before we can come at the Number or Odds against One, that what happen'd at *London* in the aforesaid *Eighty two Years*, would not have so happen'd, if the Birth of *Males* and *Females* were the result of meer Chance only.

Now if some should not be able to comprehend the foregoing Articles, as being foreign to their own Studies, let them reflect upon the Greatness of this Number, as just now express'd, and judge whether it is Credible, that in all this, Chance can be assign'd as the Cause of what is thus brought about, by any Man that ever made use of his Reason and Discretion.

SECT. XXIII. *No ignorant Laws of Nature have any place or share in these Matters.*

Now I hope no Atheist will be so desperately obstinate as, in order to quiet the Reproaches of his own Conscience (which must convince him that Chance has no room here) to ascribe these *Births*, and all the Circumstances thereof to ignorant Laws of Nature: From whence he will pretend to argue, that such Births, tho' even contrary to all the Rules of Chance, must necessarily happen after this, and no other manner. For besides that all Laws, especially those to which such a variety of things must be subservient, as in this case, before they can produce their Effects, do with great plainness lead us to a Law-giver, who has made and does keep up the same; suppose such a Philosopher were brought into a Shop where there were a great number of Clocks and Watches, all of which regularly perform'd their Functions; but that the said Machines, consisted of two kinds, (as Humane
Creatures

Creatures do of two Sexes) one sort of which, for instance, shew'd the Day of the Month and some other particular Movements; but the other, the Hour or Minutes only: Let him then tell us sincerely, whether he would dare to maintain, tho' wholly ignorant by whom and how they were made, that both these kinds of Clocks, and each of those Movements were fram'd by a necessary Law of Nature, without the Wisdom or Contrivance of an Artificer, that knew what he did, and so acquired their ingenious Structure? And whether he thinks that he himself could pass for a Man in his Senses after forming such a Judgment? There is no need of making any Application which so naturally follows of itself.

The End of the First Volume.





